

SFCTA Contract Number 06/07-29  
Caltrans EA Number 04-163701

SOUTH ACCESS TO THE GOLDEN GATE BRIDGE  
**DOYLE DRIVE**

**DOYLE DRIVE REPLACEMENT PROJECT**  
**Battery Tunnel**  
**Hydraulics Report**

**February 2009**

**Revised July 2009**

**Prepared By:**  
Arup PB Joint Venture

This Battery Tunnel Hydraulics Report has been prepared under the direction of the following Registered Engineer. The Registered Civil Engineer attests to the technical information contained herein and the engineering data upon which the recommendations, conclusions and decisions are based.

*Bori A. Touray*  
BORI TOURAY  
REGISTERED CIVIL ENGINEER

*July 27, 2009*  
DATE



California Department of  
Transportation District 4

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**Doyle Drive  
Replacement Project**

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Battery Tunnel  
Hydraulics Report

California Department of  
Transportation District 4

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This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party

Job number 131558

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## 1 Introduction

### 1.1 Purpose

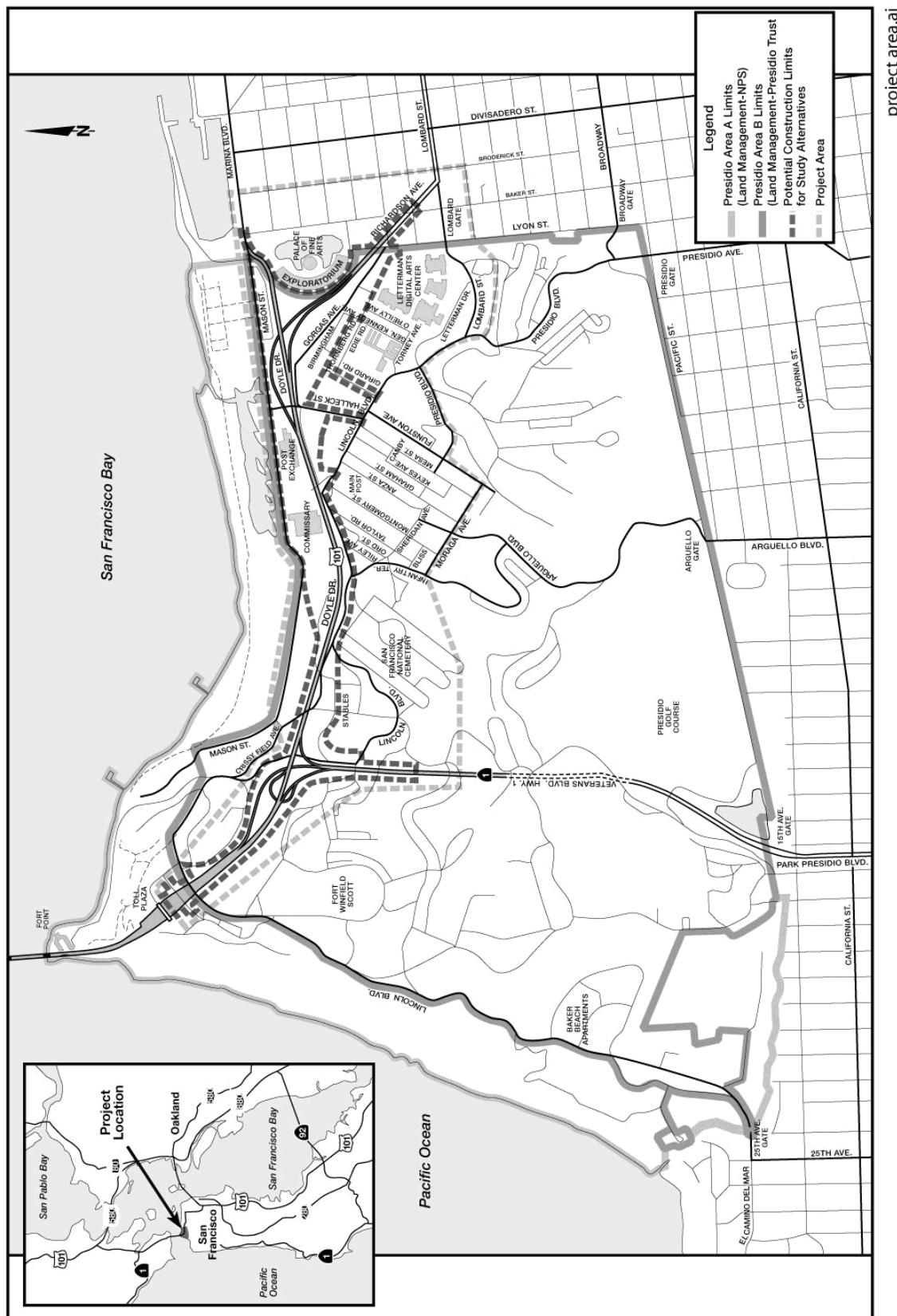
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The Caltrans "Office of Special Funded Projects (OSFP) Information and Procedures Guide" requires that a separate hydraulic report be prepared for each structure in, over or adjacent to streams and waterways which may affect the design or construction of structures (Reference 1). This report determines the water surface elevations for the proposed Battery Tunnels. The west end of the tunnels open onto the outlet of the Fort Scott watershed drainage area as it discharges into the San Francisco Bay. Under existing conditions, there is no natural stream as the channel has been covered over and the runoff is conveyed in storm drains and as surface runoff. The amount of the 100-year surface runoff is considerable and the purpose of this report is to determine if the tunnels could be inundated by the design 100-year water surface elevation. The expenditure authorization is EA 163701.

### 1.2 Background

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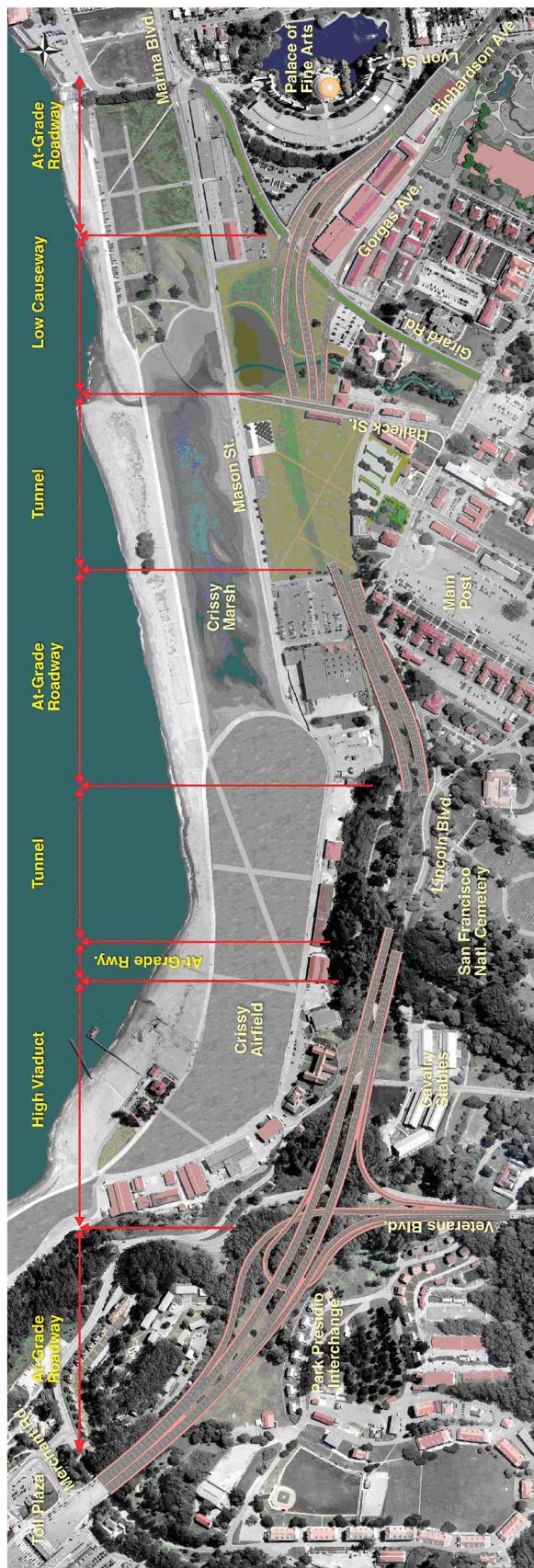
Doyle Drive Replacement Project is 1.5 linear miles and is the southern approach of Route 101 to the Golden Gate Bridge in Caltrans District 4, San Francisco County (Figure 1). Doyle Drive is approaching the end of its useful life after over 70 years of operation. In the short-term, regular maintenance, seismic retrofit, and rehabilitation activities are keeping the structure safe. In the long-term, permanent improvements are needed to bring Doyle Drive up to current design and safety standards. The San Francisco Board of Supervisors recommended that Caltrans develop a scheme that would improve safety and not increase the number of vehicles using Doyle Drive.

**Figure 1: Location Map**

## 2 Preferred Alternative

The preferred alternative will replace the existing roadway with a new six-lane facility and a southbound auxiliary lane, between the Park Presidio Interchange and the new Presidio access at Girard Road (Figure 2). The new facility will consist of two 11-foot lanes and one 12-foot outside lane in each direction with 10-foot outside shoulders and 4-foot inside shoulders. In addition, an 11-foot auxiliary lane runs along southbound Doyle Drive from the Park Presidio Interchange to the Girard Road exit ramp. The total roadway width will be 105 feet and the overall facility width including the median will vary from 122 to 146 feet. The width of the proposed landscaped median varies from 16 feet to 41 feet. To minimize impacts to the area, the footprint of the new facility will include a large portion of the existing facility's footprint east of the Park Presidio Interchange. The existing elevated Doyle Drive is supported by bents that are located approximately every 31 feet along the alignment. The lateral spacing of the bents will increase to approximately 100 feet.

The proposed facility includes an 853-foot long Battery Tunnel located at Post-Mile 9.02 to 9.26. The tunnels will consist of shallow cut-and-cover structures.

**Figure 2: Location Map**

## 3 Hydrologic Analysis

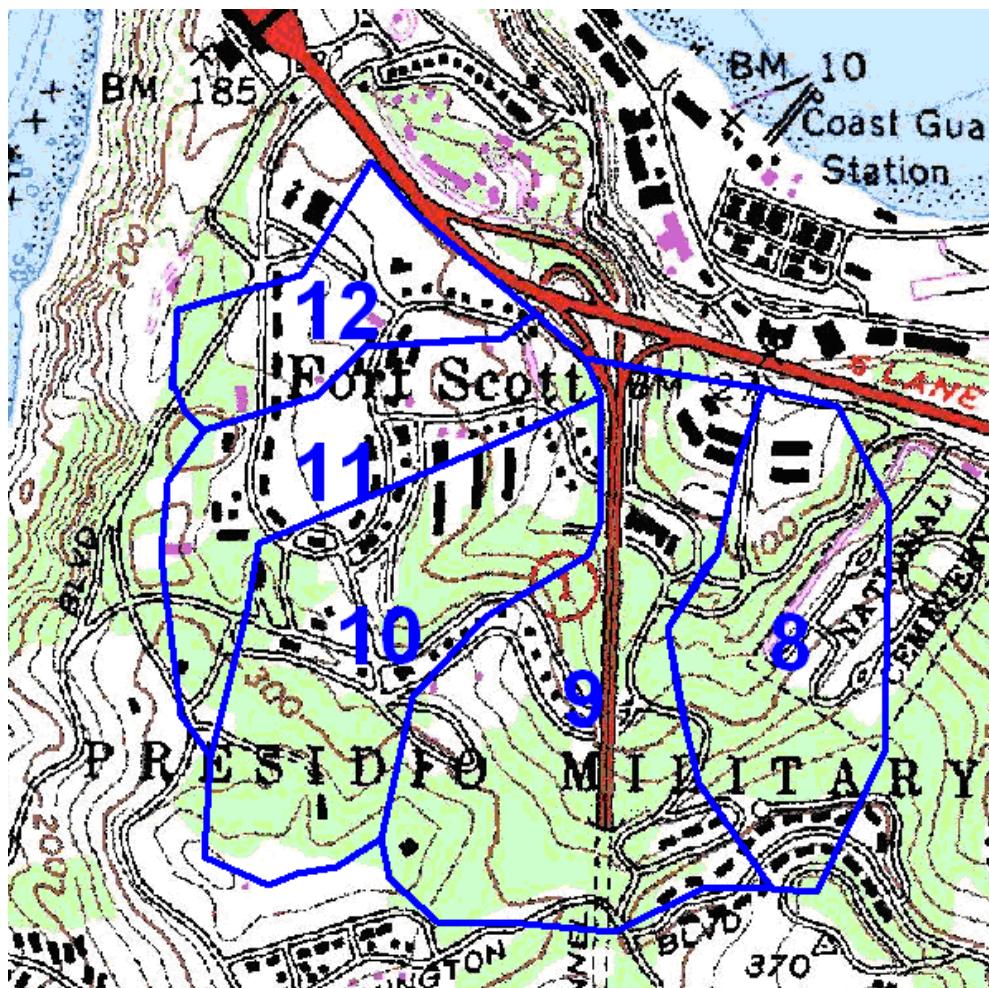
### 3.1 Approach

The US Army Corps of Engineers' HEC-HMS computer program was used to compute the 2-, 10-, 25-, 50-, 100- and 500-year watershed runoff. The program is designed to simulate the precipitation-runoff processes of dendritic watershed systems. It is designed to be applicable in a wide range of geographic areas for solving the widest possible range of problems. HEC-HMS is applicable for the analysis at the Doyle Drive site.

### 3.2 Watershed Description

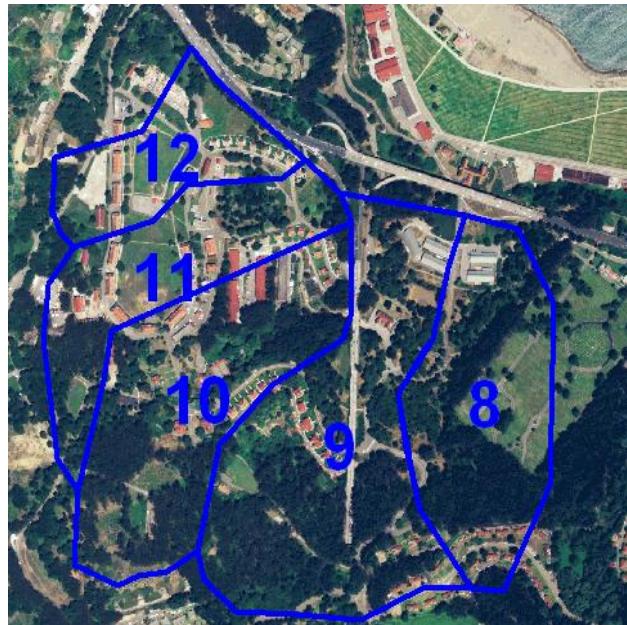
The watershed draining to the Battery Tunnel consists of approximately 229 acres of various land uses, including open space, residential, commercial, industrial, and institutional. The watershed was delineated on USGS quadrangle map (Figure 3).

Figure 3: Battery Tunnel Watershed Boundaries



There are no open channels, creeks or streams that cross the current Doyle Drive alignment. The majority of the drainage in the urban areas occurs through the Presidio storm drain system in an underground pipe network and in open channels parallel to roads. The watershed is covered by approximately 44 acres of impervious surfaces (i.e., roads, parking lots, and buildings) (Figure 4).

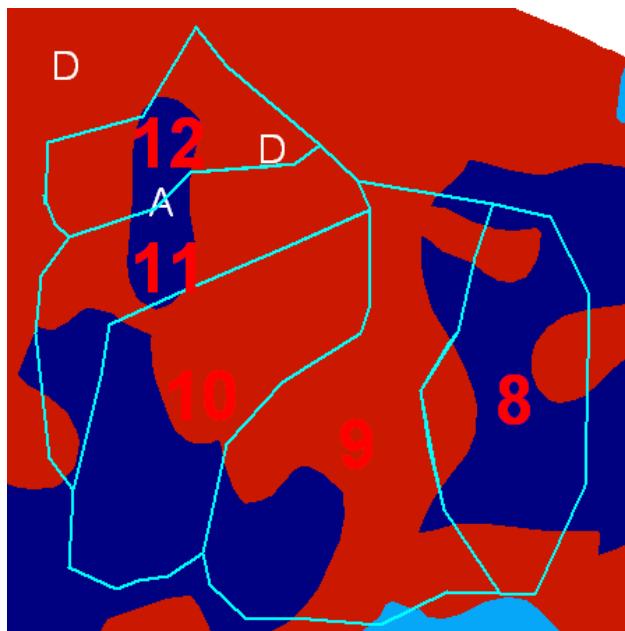
**Figure 4: Land Use**



The rain gage for San Francisco City, Gage No. E70 7772 00, with over 116 years of data was used for analyzing the runoff from the watershed. The rainfall data was obtained from the California Department of Water Resources website (Appendix A). The Natural Resource Conservation Service Hydrologic Soil Groups and curve number procedure were used to estimate rainfall infiltration. The watershed is covered by Hydrologic Soil Groups A, B and D (Figure 5). Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. A's generally have the smallest runoff potential and D's the greatest.

**Group A** is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

**Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

**Figure 5: Hydrologic Soil Groups**

**Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

**Table 1: Subbasin Areas, Impervious Cover and Hydrologic Soil Group**

SHED	HSG A (AC)	HSG B (AC)	HSG D (AC)	IMP %	Total AREA (AC)
8	28.5	0.0	16.2	11%	44.7
9	19.6	0.4	50.5	16%	70.4
10	25.1	0.0	29.1	18%	54.2
11	11.9	0.0	23.6	27%	35.5
12	5.4	0.0	18.6	37%	23.9
TOTAL	90.4	0.4	137.9	19.0	228.7

Excess runoff was transformed into flow hydrographs using the kinematic wave method. The kinematic wave method is designed principally for representing urban areas, although it can be used for undeveloped regions as well. It is a conceptual model that includes one or two representative planes. The same meteorologic boundary conditions are applied to each plane. Table 2 shows the kinematic wave parameters used for the watershed.

**Table 2: Kinematic Wave Parameters for Pervious Areas**

OVERLAND				
SHED	LENGTH (FT)	US EL	DS EL	SLOPE
8	300	360	306	0.1797
9	300	360	329	0.1027
10	300	360	340	0.0661
11	300	325	308	0.0558
12	300	310	279	0.1022
COLLECTOR CHANNEL				
SHED	LENGTH (FT)	US EL	DS EL	SLOPE
8	841	306	155	0.1797
9	430	329	285	0.1027
10	834	340	285	0.0661
11	506	308	280	0.0558
12	434	279	235	0.1022
MAIN CHANNEL				
SHED	LENGTH (FT)	US EL	DS EL	SLOPE
8	1513	155	30	0.0826
9	2569	285	30	0.0993
10	1823	285	120	0.0905
11	2488	280	130	0.0603
12	1060	235	165	0.0660

The storm drains do not have the capacity to convey even the 10-year event according to Dames and Moore who performed a detailed analysis of the system in 1994 (Reference 2).

Most of the flow in the 10-year event and events higher than the 10-year will be surface runoff instead of storm drain flow. The storm drain system has therefore been neglected in this study.

### 3.3 Results

Table 3 shows the existing 100-year flows at Doyle Drive. There are no stream gages in the watershed and the model could not be calibrated to accurately represent the area. To provide a sense of how reasonable the results may be, the watershed was analyzed using National Flood Frequency (NFF) Program regression equations for the central coast region of California (Appendix A). The National Flood Frequency (NFF) Program provides equations for estimating the magnitude and recurrence intervals for floods in urbanized areas throughout the conterminous United States and Hawaii. These equations have been thoroughly tested and proven to give reasonable estimates for floods having recurrence intervals between 2 and 500 years. The comparison indicates that the HEC-HMS 100-year flow is approximately 18% higher than the regression equations.

The results are greater than those presented in the Dames and Moore report entitled "Presidio of San Francisco Storm Water Management Plan" October 1994. The difference is due to the short duration storm used by Dames and Moore.

**Table 3: Flows at Battery Tunnel**

RECURRANCE INTERVAL (YEARS)	PEAK FLOW (CFS)		% DIFFERENCE
	HEC-HMS	REGRESSION	
2	171	139	18.7
10	321	284	11.5
25	399	335	16.0
50	464	388	16.4
100	530	433	18.3
500	685	501	26.9

## 4 Hydraulic Analysis

### 4.1 Approach

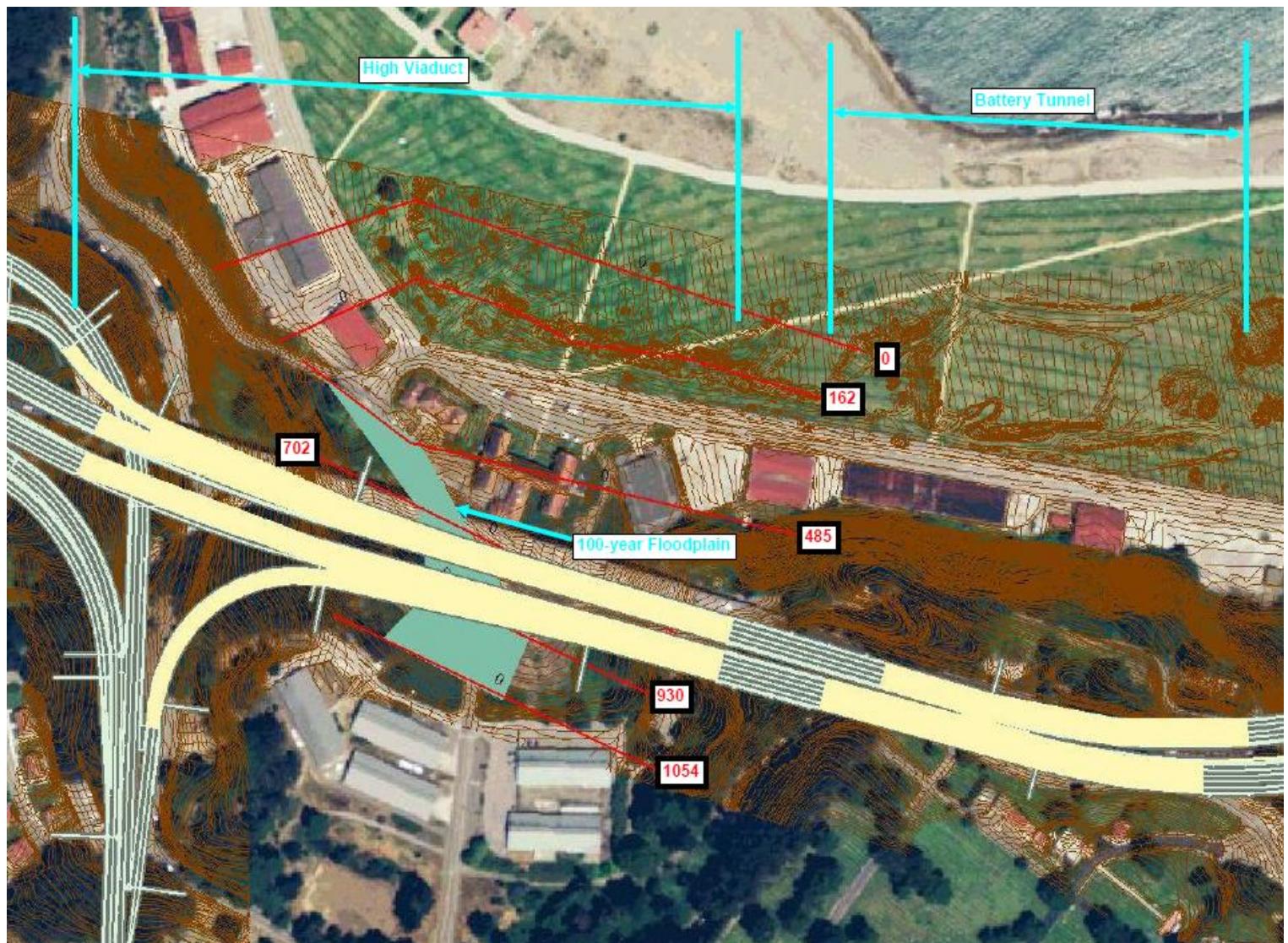
The project site is not located in a Federal Emergency Management Agency's (FEMA) flood hazard zone. The US Army Corps of Engineers HEC-RAS computer program was used to compute the water surface elevations and velocities for the watershed runoff draining to the Battery Tunnels. HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program was developed by the US Army Corps of Engineers Hydrologic Engineering Center. It includes numerous data entry capabilities, hydraulic analysis components, data storage and management capabilities, and graphing and reporting capabilities. HEC-RAS is capable of both steady and unsteady flow analysis. HEC-RAS is equipped to model a network of channels, a dendritic system or a single river reach.

## 4.2 Water Surface Elevations and Velocities

Water surface elevations were computed in HEC-RAS for the watershed runoff (Table 4). The anticipated 100-year tsunami water surface of 11.2 feet NAVD 88 in the vicinity of the Battery Tunnels is lower than the natural ground at the Battery Tunnels and will therefore not affect the water surface elevations.

**Table 4: Water Surface Elevations and Velocities at Battery Tunnel**

Water Surface Elevation (ft NAVD 88)				
River Sta	50-year	100-year	500-year	
0	14.9	15.2	15.8	
162	15.2	15.3	15.9	
485	15.8	15.9	15.9	
702	28.7	28.8	29.2	DS Doyle Drive
930	44.3	44.4	44.5	US Doyle Drive
1054	51.6	51.7	51.9	

**Figure 6: 100-year Floodplain**

## 5 References and Bibliography

- [1] OSFP Information and Procedures Guide, June 20027
- [2] Dames & Moore. *Presidio of San Francisco Storm Water Management Plan*, October 1994.
- [3] HEC-18 - Evaluating Scour at Bridges, Resource Consultants and Engineers, National Highway Institute, Federal Highway Administration, 6200 Georgetown Pike, Mclean, Virginia 22101.
- [4] United States Environmental Protection Agency. *The Probability of Sea Level Rise*, EPA 230-R-95-008. October 1995.
- [5] Houston, J.R. and A.W. Garcia. Type 16 Flood Insurance Study: Tsunami Predictions for Monterey and San Francisco Bays and Puget Sound, Technical Report H-75-17, November 1975
- [6] Manna Consultants. *Draft Technical Memorandum, Location Hydraulics Study*. November 17, 2000.

## 6 Appendices

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## Appendix A: Hydrology

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## Rainfall Depth Duration Frequency

Station	Statio No	County	Lat	Long.	Elev.	Source	Yrs Rec	Slope	Intercep
San Francisco City	E70 7772 00	San Fr:	#####	#####	50	HPD	116	0.459	0.561

Maximum Rainfall For Indicated Number Of Consecutive Days													
	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	1 Day	2 Day	3 Day	C-Yr
RP 2	0.16	0.23	0.28	0.37	0.50	0.71	0.85	1.20	1.59	2.11	#DIV/0!	#DIV/0!	20.84
RP 5	0.23	0.32	0.39	0.53	0.71	1.00	1.20	1.68	2.24	2.96	#DIV/0!	#DIV/0!	27.25
RP 10	0.27	0.38	0.47	0.63	0.85	1.19	1.43	2.01	2.67	3.53	#DIV/0!	#DIV/0!	30.95
RP 25	0.32	0.46	0.56	0.75	1.02	1.43	1.72	2.41	3.22	4.25	#DIV/0!	#DIV/0!	35.19
RP 50	0.36	0.52	0.63	0.85	1.14	1.61	1.94	2.71	3.61	4.77	#DIV/0!	#DIV/0!	38.09
RP 100	0.40	0.58	0.70	0.94	1.27	1.78	2.15	3.00	4.00	5.29	#DIV/0!	#DIV/0!	40.80
RP 200	0.44	0.63	0.77	1.03	1.39	1.95	2.35	3.29	4.39	5.80	#DIV/0!	#DIV/0!	43.37
RP 500	0.49	0.70	0.86	1.15	1.55	2.18	2.62	3.67	4.90	6.47	#DIV/0!	#DIV/0!	46.62
RP 1000	0.53	0.76	0.93	1.24	1.67	2.35	2.83	3.96	5.28	6.97	#DIV/0!	#DIV/0!	48.97
RP 10000	0.66	0.94	1.15	1.53	2.07	2.91	3.51	4.91	6.54	8.64	#DIV/0!	#DIV/0!	56.35
Average	0.18	0.25	0.31	0.41	0.55	0.77	0.93	1.31	1.74	2.30	#DIV/0!	#DIV/0!	21.43
Stdev	0.06	0.09	0.11	0.14	0.18	0.22	0.30	0.46	0.69	0.96	#DIV/0!	#DIV/0!	7.03
Rec Max	0.38	0.51	0.65	0.83	1.07	1.46	2.27	4.00	6.00	7.76	0.00	0.00	45.59
Rec Min	0.07	0.09	0.11	0.18	0.26	0.37	0.46	0.74	0.89	1.17	0.00	0.00	9.00
Z	2.90	2.57	2.79	2.56	2.33	2.20	3.55	<b>5.11</b>	<b>6.06</b>	<b>5.89</b>	#DIV/0!	#DIV/0!	3.35
Yrs Rec	78	78	78	78	97	98	116	116	116	116	0	0	115
Calc CV	0.343	0.356	0.363	0.350	0.325	0.290	0.326	0.350	0.397	0.420	#DIV/0!	#DIV/0!	0.328
Reg CV	.404	.404	.404	.404	.404	.404	.404	.404	.404	.404	.431	.426	.336
Skew	0.9	0.9	0.9	0.9	0.7	0.9	1.8	2.8	3.3	2.7	#DIV/0!	#DIV/0!	0.9
Reg Skew	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	0.5
Kurtosis	0.9	0.5	0.5	0.6	-0.1	0.5	4.5	12.2	16.1	11.1	#DIV/0!	#DIV/0!	1.5

Maximum Rainfall For Indicated Number Of Consecutive Days

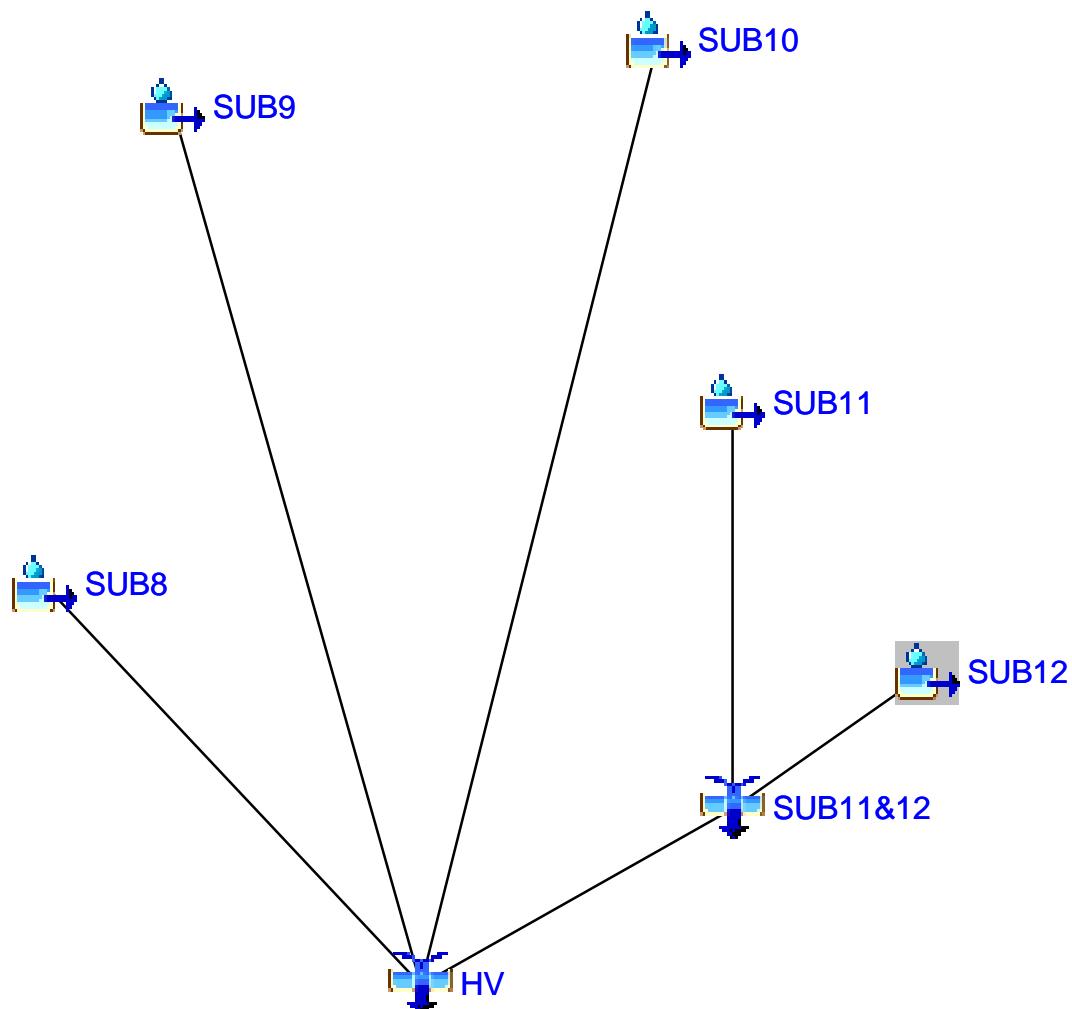


HEC-HMS

## Project : HMS-NEW

Basin Model : Basin 1

Jul 25 08:30:54 PDT 2009



Project: HMS-NEW Simulation Run: 2-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1  
End of Run: 16Jul2008, 00:05 Meteorologic Model: 2-year  
Compute Time: 25Jul2009, 08:31:49 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	170.7	15Jul2008, 10:05	1.72
SUB10	0.0847	37.7	15Jul2008, 10:05	1.72
SUB11	0.0554	22.5	15Jul2008, 10:05	1.60
SUB11&12	0.0928	39.2	15Jul2008, 10:05	1.57
SUB12	0.0374	16.7	15Jul2008, 10:05	1.53
SUB8	0.0699	39.7	15Jul2008, 10:05	1.84
SUB9	0.1100	54.1	15Jul2008, 10:05	1.76

Project: HMS-NEW Simulation Run: 10-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1  
End of Run: 16Jul2008, 00:05 Meteorologic Model: 10-year  
Compute Time: 25Jul2009, 08:31:40 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	320.9	15Jul2008, 10:05	2.92
SUB10	0.0847	73.1	15Jul2008, 10:05	2.91
SUB11	0.0554	43.8	15Jul2008, 10:05	2.73
SUB11&12	0.0928	74.0	15Jul2008, 10:05	2.68
SUB12	0.0374	31.7	15Jul2008, 10:00	2.61
SUB8	0.0699	73.2	15Jul2008, 10:00	3.11
SUB9	0.1100	101.8	15Jul2008, 10:05	3.00

Project: HMS-NEW Simulation Run: 25-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1  
End of Run: 16Jul2008, 00:05 Meteorologic Model: 25-year  
Compute Time: 25Jul2009, 08:31:45 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	399.2	15Jul2008, 10:00	3.53
SUB10	0.0847	91.1	15Jul2008, 10:05	3.53
SUB11	0.0554	54.9	15Jul2008, 10:05	3.30
SUB11&12	0.0928	91.9	15Jul2008, 10:05	3.24
SUB12	0.0374	40.0	15Jul2008, 10:00	3.15
SUB8	0.0699	92.5	15Jul2008, 10:00	3.76
SUB9	0.1100	128.6	15Jul2008, 10:00	3.64

Project: HMS-NEW Simulation Run: 50-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1  
End of Run: 16Jul2008, 00:05 Meteorologic Model: 50-year  
Compute Time: 25Jul2009, 08:31:59 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	464.1	15Jul2008, 10:00	3.98
SUB10	0.0847	104.6	15Jul2008, 10:05	3.97
SUB11	0.0554	63.1	15Jul2008, 10:05	3.71
SUB11&12	0.0928	106.1	15Jul2008, 10:00	3.65
SUB12	0.0374	46.0	15Jul2008, 10:00	3.55
SUB8	0.0699	107.2	15Jul2008, 10:00	4.23
SUB9	0.1100	149.2	15Jul2008, 10:00	4.11

Project: HMS-NEW Simulation Run: 100-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1  
End of Run: 16Jul2008, 00:05 Meteorologic Model: 100-year  
Compute Time: 25Jul2009, 08:31:35 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	530.3	15Jul2008, 10:00	4.43
SUB10	0.0847	118.3	15Jul2008, 10:05	4.43
SUB11	0.0554	71.2	15Jul2008, 10:05	4.13
SUB11&12	0.0928	121.3	15Jul2008, 10:00	4.06
SUB12	0.0374	52.2	15Jul2008, 10:00	3.94
SUB8	0.0699	121.9	15Jul2008, 10:00	4.70
SUB9	0.1100	171.2	15Jul2008, 10:00	4.58

Project: HMS-NEW Simulation Run: 500-year

Start of Run: 15Jul2008, 00:00 Basin Model: Basin 1  
End of Run: 16Jul2008, 00:05 Meteorologic Model: 500-yaer  
Compute Time: 25Jul2009, 08:31:54 Control Specifications: Control 1

Volume Units: IN

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
HV	0.3574	684.8	15Jul2008, 10:00	5.47
SUB10	0.0847	151.9	15Jul2008, 10:00	5.47
SUB11	0.0554	89.7	15Jul2008, 10:00	5.10
SUB11&12	0.0928	156.0	15Jul2008, 10:00	5.00
SUB12	0.0374	66.3	15Jul2008, 10:00	4.84
SUB8	0.0699	154.5	15Jul2008, 10:00	5.78
SUB9	0.1100	222.4	15Jul2008, 10:00	5.67

National Flood Frequency Program  
Version 3.0  
Based on Water-Resources Investigations Report 02-4168  
Equations from database C:\Program Files\NFF\NFFv3.2\_2004-12-14.mdb  
Updated by kries 9/22/2004 at 4:03:24 PM fixed decimal place in constant  
Equations for California developed using English units

Site: High Viaduct, California  
User: touray  
Date: Saturday, July 25, 2009 09:27 AM

Rural Estimate: Rural 2  
Basin Drainage Area: 0.36 mi<sup>2</sup>  
1 Region  
Region: Central\_Coast\_Region  
Drainage\_Area = 0.36 mi<sup>2</sup>  
Mean\_Annual\_Precipitation = 21.4 in  
Altitude\_Index = 0.1 thousand feet  
Crippen & Bue Region 17

Urban Estimate: Urban 2  
Basin Drainage Area: 0.36 mi<sup>2</sup>  
1 Region  
Region: National Urban  
Drainage\_Area = 0.36 mi<sup>2</sup>  
Channel\_Slope = 70 ft per mi  
2-hour\_2-year\_Rainfall\_Intensity = 2.49 in  
Basin\_Storage = 0 percent  
Basin\_Development\_Factor = 5 dimensionless  
Impervious\_Surfaces = 19 percent  
Rural Scenario = Rural 2

Flood Peak Discharges, in cubic feet per second

Estimate	Recurrence Interval, yrs	Peak, cfs	Standard Error, %	Equivalent Years
Rural 2	2	71.3	150	
	5	112	110	
	10	140	96	
	25	175	96	
	50	198	110	
	100	223	120	
	500	278		
maximum: 2260 (for C&B region 17)				
Urban 2	2	160	38	
	5	244	37	
	10	306	38	
	25	370	40	
	50	434	42	
	100	489	44	
	500	600	49	

## Appendix B: Hydraulics

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HEC-RAS Version 4.0.0 March 2008  
U.S. Army Corps of Engineers  
Hydrologic Engineering Center  
609 Second Street  
Davis, California

X	X	XXXXXX	XXXX	XXXX	XX	XXXX
X	X	X	X X	X X	X X	X
X	X	X	X	X X	X X	X
XXXXXX	XXXX	X	XXX	XXXX	XXXXXX	XXXX
X	X	X	X	X X	X X	X
X	X	X	X X	X X	X X	X
X	X	XXXXXX	XXXX	X X	X X	XXXXXX

#### PROJECT DATA

Project Title: High Viaduct  
Project File : HV.prj  
Run Date and Time: 7/24/2009 4:36:30 PM

Project in English units

#### PLAN DATA

Plan Title: Scour  
Plan File : C:\Desktop\Doyle\OUTBOX\Models\RAS\HV.p02

Geometry Title: High Viaduct  
Geometry File : C:\Desktop\Doyle\OUTBOX\Models\RAS\HV.g01

Flow Title : High Viaduct  
Flow File : C:\Desktop\Doyle\OUTBOX\Models\RAS\HV.f02

#### Plan Summary Information:

Number of: Cross Sections = 6    Multiple Openings = 0  
Culverts = 0    Inline Structures = 0  
Bridges = 1    Lateral Structures = 0

#### Computational Information

Water surface calculation tolerance = 0.01  
Critical depth calculation tolerance = 0.01  
Maximum number of iterations = 20  
Maximum difference tolerance = 0.3  
Flow tolerance factor = 0.001

#### Computation Options

Critical depth computed only where necessary  
Conveyance Calculation Method: At breaks in n values only  
Friction Slope Method: Average Conveyance  
Computational Flow Regime: Subcritical Flow

#### FLOW DATA

Flow Title: High Viaduct  
Flow File : C:\Desktop\Doyle\OUTBOX\Models\RAS\HV.f02

Flow Data (cfs)

River	Reach	RS	2-year	10-year	25-year
50-year	100-year	500-year			
High	Viaduct	1054			
464	530	685	171	321	399

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
High	Viaduct	2-year		Normal S = 0.002
High	Viaduct	10-year		Normal S = 0.002
High	Viaduct	25-year		Normal S = 0.002
High	Viaduct	50-year		Normal S = 0.002
High	Viaduct	100-year		Normal S = 0.002
High	Viaduct	500-year		Normal S = 0.002

GEOMETRY DATA

Geometry Title: High Viaduct  
 Geometry File : C:\Desktop\Doyle\OUTBOX\Models\RAS\HV.g01

CROSS SECTION

RIVER: High  
 REACH: Viaduct RS: 1054

INPUT

Description:

Station	Elevation	Data num=	266	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	65.9	2.2	65.7	4.4	65.7	6.6	65.5	8.8	65		
11	64.3	13.2	64.3	15.4	64.2	17.6	64	19.8	63.2		
22	63.3	24.2	62.6	26.4	62.6	28.6	62	30.8	61.6		
33	61.6	35.2	61.5	37.4	62.3	39.6	62.1	41.9	62.6		
44.1	62.3	46.3	61.7	48.5	60.7	50.7	60.4	52.9	60.4		
55.1	60.8	57.3	59.9	59.5	59.6	61.7	59.9	63.9	59.5		
68.3	59.5	70.5	59.6	72.7	59.5	74.9	59.5	77.1	59.4		
85.9	59.4	88.1	58.7	92.5	58.7	96.9	58.5	99.1	58.5		
101.3	58.4	103.5	58.4	105.7	58.3	107.9	58.4	110.1	58.3		
112.3	58.4	114.5	57.9	116.7	57.6	118.9	57.6	121.2	57.5		
123.4	57.6	125.6	57.5	127.8	57.6	134.4	57.3	136.6	57.3		
138.8	56.8	141	56.8	143.2	56.7	145.4	56.5	149.8	56.3		
152	56.1	154.2	55.8	156.4	55.6	158.6	55.5	163	55.1		
165.2	55	171.8	55	174	54.5	176.2	54.8	178.4	54.7		
180.6	55	182.8	55	185	55.1	187.2	55.1	189.4	55.3		
191.6	55.2	193.8	55.3	196	55.2	198.2	55.3	200.4	55.3		
202.7	55.2	204.9	55.3	207.1	55.2	209.3	55.3	211.5	55.3		
213.7	55.1	215.9	54.7	218.1	55	222.5	55	224.7	54.9		
231.3	54.9	235.7	54.7	237.9	54.8	240.1	54.7	242.3	54.7		
244.5	54.6	246.7	54.7	248.9	54.5	253.3	54.5	255.5	54.4		
259.9	54.4	262.1	54.5	264.3	54.4	266.5	54.5	273.1	54.5		
275.3	54.6	279.7	54.6	282	54.5	284.2	54.5	286.4	54.4		
288.6	54.4	293	54.2	299.6	54.2	301.8	54.1	304	54.1		
306.2	53.9	310.6	53.7	315	53.7	317.2	53.6	319.4	53.6		
321.6	53.1	323.8	52.9	326	52.3	328.2	51.7	330.4	51.5		
332.6	50.8	334.8	50.6	337	50.4	339.2	50.4	341.4	50.4		
343.6	50.4	345.8	50.2	348	50.5	350.2	50.1	352.4	49.9		
354.6	49.7	356.8	49.9	359	49.8	361.2	50.1	363.5	50.2		
365.7	50.3	367.9	50.4	370.1	50.5	372.3	50.5	374.5	50.5		
376.7	50.5	378.9	50.5	381.1	50.8	383.3	50.8	385.5	51		
387.7	51	389.9	51	392.1	51	394.3	51	396.5	51		
398.7	51	400.9	51	403.1	51	405.3	51	407.5	51		
409.7	51	411.9	51	414.1	51.2	416.3	51.2	418.5	51.6		
420.7	51.4	422.9	51.6	425.1	51.6	427.3	52.1	429.5	52		
431.7	52.5	433.9	52.8	436.1	52.8	438.3	53	440.5	53		
442.8	53.3	445	53	447.2	53.6	449.4	53	451.6	54		
453.8	53.8	456	54.5	458.2	54.2	460.4	54.5	462.6	55		
464.8	55.2	467	55.9	469.2	56	471.4	56.2	473.6	56.5		
475.8	56.7	478	56.6	480.2	56.8	482.4	56.8	484.6	57		
489	56.8	491.2	57	493.4	57	495.6	57.3	497.8	57.2		
500	57.3	502.2	57.3	504.4	57.5	508.8	57.5	511	57.6		
513.2	57.8	517.6	58	535.3	58	537.5	58.1	539.7	58.1		
541.9	58.3	550.7	58.3	552.9	58.5	559.5	58.5	561.7	58.6		
568.3	58.6	570.5	59.4	574.9	59.4	577.1	59.5	585.9	59.5		

588.1	59.6	596.9	59.6	599.1	59.7	603.6	59.7	605.8	60
608	60	610.2	60.2	612.4	60.2	619	60.5	621.2	60.5
623.4	60.6	625.6	60.6	627.8	60.7	630	60.7	632.2	60.8
636.6	61.2	638.8	61.5	641	61.5	643.2	61.8	645.4	62
654.2	62	656.4	62.1	658.6	62.6	660.8	62.7	663	63
665.2	63	667.4	63.1	669.6	63.3	671.8	64	674	64
676.2	64.4	678.4	64.4	682.8	65.6	685.1	65.8	687.3	66.4
693.9	66.7	696.1	67.3	698.3	67.7	704.9	68	707.1	68.2
709.3	68.7	711.5	68.8	713.7	69.1	715.9	69.3	718.1	69.6
720.3	70								

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val  
 0 .06 321.6 .06 433.9 .06

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.  
 321.6 433.9 124 124 124 .1 .3

#### CROSS SECTION

RIVER: High  
 REACH: Viaduct RS: 930

#### INPUT

##### Description:

Station	Elevation	Data	num=	258					
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	54.1	2.2	54	4.4	53.3	6.6	53	8.8	52.8
10.9	52	13.1	52	15.3	51.2	17.5	51.2	19.7	50.8
21.9	50.2	24.1	50.2	26.3	49.8	28.4	49.7	30.6	49.1
32.8	49	35	47.8	37.2	47.9	39.4	47.7	41.6	47.6
43.8	47.8	45.9	47.6	48.1	48	50.3	47.8	52.5	47.7
54.7	47.4	56.9	47.4	61.3	46.4	63.4	46.7	65.6	47
67.8	47	70	47.2	72.2	47.2	74.4	47.3	78.8	47.3
81	47.5	83.1	47.8	85.3	47.6	87.5	48	89.7	48
91.9	48.2	94.1	48	96.3	48.2	98.5	48.1	100.6	48
102.8	48.3	105	48.2	107.2	48.2	109.4	48	111.6	48.2
113.8	47.9	116	48.4	118.1	48.4	120.3	48.3	122.5	48.3
126.9	48.1	129.1	47.9	131.3	47.9	133.5	47.7	137.8	47.7
140	47.6	144.4	47.2	153.2	46.8	159.7	46.8	161.9	47.2
164.1	47.2	166.3	47.3	170.7	47.1	172.8	47	175	47
177.2	46.9	179.4	46.7	181.6	46.4	183.8	46	192.5	46
194.7	45.8	196.9	45.9	199.1	45.7	201.3	45.8	203.5	45.7
205.7	45.8	207.9	45.3	210	45.4	212.2	45.1	214.4	44.7
216.6	44.2	221	44.2	225.4	43.8	227.5	43.8	229.7	44
231.9	43.9	234.1	43.9	236.3	44	247.2	44	249.4	44.1
251.6	44	253.8	44	256	44.6	258.2	44.5	260.4	44.9
262.5	44.1	264.7	44.7	266.9	43.9	269.1	44.2	271.3	44.3
273.5	44.1	275.7	44.5	277.9	44.4	282.2	44.4	284.4	44.3
291	44.3	295.4	44.1	297.6	43.7	299.7	43.5	304.1	43.1
306.3	43	310.7	43	315.1	43.8	317.2	43.8	319.4	44
321.6	44	326	43.8	328.2	43.8	332.6	43.6	334.7	43.6
336.9	43.5	339.1	43.6	341.3	43.4	343.5	43.4	345.7	43.3
347.9	43.6	350.1	43.7	352.3	43.7	354.4	43.9	356.6	43.9
358.8	44	361	44	363.2	43.7	365.4	43.5	369.8	43.3
371.9	43	374.1	43.1	376.3	43	378.5	43	380.7	42.9
382.9	43	385.1	42.8	387.3	43	389.4	43	391.6	42.9
393.8	42.7	396	42.6	398.2	42.8	400.4	42.8	402.6	42.7
404.8	42.6	407	42.5	409.1	42.3	411.3	42.3	413.5	42.3
415.7	42.4	417.9	42.5	420.1	42.5	422.3	42.5	424.5	42.6
426.6	42.7	428.8	42.5	431	42.6	433.2	42.6	435.4	42.6
437.6	42.6	439.8	42.6	442	42.6	444.1	42.6	446.3	42.6
448.5	43.1	452.9	43.1	455.1	43.3	457.3	43.4	459.5	43.4
461.6	43.5	466	43.7	470.4	43.7	472.6	43.8	474.8	43.8
479.2	44	492.3	44	494.5	44.2	496.7	44.3	498.8	44.4
501	44.6	505.4	44.6	507.6	45	512	45.4	514.2	45.5
520.7	45.5	529.5	46.3	531.7	46.3	533.8	46.5	538.2	46.5
540.4	47.3	542.6	47.6	547	47.6	551.4	47.8	553.5	48.3
555.7	48.5	557.9	48.5	560.1	48.7	562.3	48.7	564.5	48.8
566.7	49.1	568.9	49.3	571	49.7	573.2	49.9	575.4	50
577.6	50	582	50.6	584.2	51	597.3	51	599.5	52
614.8	52	617	52.2	619.2	52.9	621.4	53	632.3	53
634.5	53.3	636.7	53.7	638.9	54	645.4	54	647.6	54.1

649.8	54.6	652	54.9	654.2	55	656.4	55	658.6	55.3
660.7	55.7	662.9	56	667.3	56	673.9	56.9	676.1	57.3
678.3	57.6	680.4	57.7	682.6	58.2	684.8	58.4	687	58.5
689.2	58.9	691.4	59.5	693.6	59.5	695.8	59.9	697.9	60.4
700.1	60.4	702.3	61.2	708.9	62.4	711.1	62.6	713.3	63.6
715.4	63.8	717.6	64.7	719.8	65.2				

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val  
 0 .06 0 .06 719.8 .06

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.  
 0 719.8 228 228 228 .1 .3  
 Ineffective Flow num= 2  
 Sta L Sta R Elev Permanent  
 0 0 54.1 F  
 719.8 719.8 65.2 F

BRIDGE

RIVER: High  
 REACH: Viaduct RS: 816

INPUT

Description:

Distance from Upstream XS = 10

Deck/Roadway Width = 200

Weir Coefficient = 2.6

Upstream Deck/Roadway Coordinates

	Sta	Hi	Cord	Lo	Cord	Sta	Hi	Cord	Lo	Cord
	0	60	55	700	60	0	700	60	55	

Upstream Bridge Cross Section Data

Station	Elevation	Data	num= 258	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	
				0	54.1	2.2	54	4.4	53.3	6.6	53	8.8
10.9	52	13.1		52	15.3	51.2	17.5	51.2	19.7	50.8		
21.9	50.2	24.1		50.2	26.3	49.8	28.4	49.7	30.6	49.1		
32.8	49	35		47.8	37.2	47.9	39.4	47.7	41.6	47.6		
43.8	47.8	45.9		47.6	48.1	48	50.3	47.8	52.5	47.7		
54.7	47.4	56.9		47.4	61.3	46.4	63.4	46.7	65.6	47		
67.8	47	70		47.2	72.2	47.2	74.4	47.3	78.8	47.3		
81	47.5	83.1		47.8	85.3	47.6	87.5	48	89.7	48		
91.9	48.2	94.1		48	96.3	48.2	98.5	48.1	100.6	48		
102.8	48.3	105		48.2	107.2	48.2	109.4	48	111.6	48.2		
113.8	47.9	116		48.4	118.1	48.4	120.3	48.3	122.5	48.3		
126.9	48.1	129.1		47.9	131.3	47.9	133.5	47.7	137.8	47.7		
140	47.6	144.4		47.2	153.2	46.8	159.7	46.8	161.9	47.2		
164.1	47.2	166.3		47.3	170.7	47.1	172.8	47	175	47		
177.2	46.9	179.4		46.7	181.6	46.4	183.8	46	192.5	46		
194.7	45.8	196.9		45.9	199.1	45.7	201.3	45.8	203.5	45.7		
205.7	45.8	207.9		45.3	210	45.4	212.2	45.1	214.4	44.7		
216.6	44.2	221		44.2	225.4	43.8	227.5	43.8	229.7	44		
231.9	43.9	234.1		43.9	236.3	44	247.2	44	249.4	44.1		
251.6	44	253.8		44	256	44.6	258.2	44.5	260.4	44.9		
262.5	44.1	264.7		44.7	266.9	43.9	269.1	44.2	271.3	44.3		
273.5	44.1	275.7		44.5	277.9	44.4	282.2	44.4	284.4	44.3		
291	44.3	295.4		44.1	297.6	43.7	299.7	43.5	304.1	43.1		
306.3	43	310.7		43	315.1	43.8	317.2	43.8	319.4	44		
321.6	44	326		43.8	328.2	43.8	332.6	43.6	334.7	43.6		
336.9	43.5	339.1		43.6	341.3	43.4	343.5	43.4	345.7	43.3		
347.9	43.6	350.1		43.7	352.3	43.7	354.4	43.9	356.6	43.9		
358.8	44	361		44	363.2	43.7	365.4	43.5	369.8	43.3		
371.9	43	374.1		43.1	376.3	43	378.5	43	380.7	42.9		
382.9	43	385.1		42.8	387.3	43	389.4	43	391.6	42.9		
393.8	42.7	396		42.6	398.2	42.8	400.4	42.8	402.6	42.7		
404.8	42.6	407		42.5	409.1	42.3	411.3	42.3	413.5	42.3		
415.7	42.4	417.9		42.5	420.1	42.5	422.3	42.5	424.5	42.6		
426.6	42.7	428.8		42.5	431	42.6	433.2	42.6	435.4	42.6		
437.6	42.6	439.8		42.6	442	42.6	444.1	42.6	446.3	42.6		
448.5	43.1	452.9		43.1	455.1	43.3	457.3	43.4	459.5	43.4		
461.6	43.5	466		43.7	470.4	43.7	472.6	43.8	474.8	43.8		

479.2	44	492.3	44	494.5	44.2	496.7	44.3	498.8	44.4
501	44.6	505.4	44.6	507.6	45	512	45.4	514.2	45.5
520.7	45.5	529.5	46.3	531.7	46.3	533.8	46.5	538.2	46.5
540.4	47.3	542.6	47.6	547	47.6	551.4	47.8	553.5	48.3
555.7	48.5	557.9	48.5	560.1	48.7	562.3	48.7	564.5	48.8
566.7	49.1	568.9	49.3	571	49.7	573.2	49.9	575.4	50
577.6	50	582	50.6	584.2	51	597.3	51	599.5	52
614.8	52	617	52.2	619.2	52.9	621.4	53	632.3	53
634.5	53.3	636.7	53.7	638.9	54	645.4	54	647.6	54.1
649.8	54.6	652	54.9	654.2	55	656.4	55	658.6	55.3
660.7	55.7	662.9	56	667.3	56	673.9	56.9	676.1	57.3
678.3	57.6	680.4	57.7	682.6	58.2	684.8	58.4	687	58.5
689.2	58.9	691.4	59.5	693.6	59.5	695.8	59.9	697.9	60.4
700.1	60.4	702.3	61.2	708.9	62.4	711.1	62.6	713.3	63.6
715.4	63.8	717.6	64.7	719.8	65.2				

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val  
 0 .06 0 .06 719.8 .06

Bank Sta: Left Right Coeff Contr. Expan.  
 0 719.8 .1 .3

Ineffective Flow num= 2  
 Sta L Sta R Elev Permanent  
 0 0 54.1 F  
 719.8 719.8 65.2 F

Downstream Deck/Roadway Coordinates  
 num= 2  
 Sta Hi Cord Lo Cord Sta Hi Cord Lo Cord  
 0 60 55 781 60 55

Downstream Bridge Cross Section Data  
 Station Elevation Data num= 339  
 Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev  
 0 52.1 2.2 50.9 4.4 50.2 6.6 49.2 8.9 49  
 11.1 47.4 13.3 47 15.5 45.7 19.9 44.5 22.1 44.6  
 24.3 43.4 26.6 42.4 28.8 41.8 31 40.7 33.2 41  
 35.4 40.3 37.6 39.8 39.8 38.8 42.1 38.5 44.3 37.5  
 46.5 37.4 48.7 36.6 50.9 36.2 55.3 35.2 57.5 35  
 59.8 34.6 62 33.8 64.2 33.8 66.4 33.3 68.6 32.7  
 70.8 32.8 73 32.5 75.3 32.6 77.5 32.2 79.7 32.2  
 81.9 31.9 84.1 31.4 86.3 30.4 90.7 29.2 93 29.2  
 95.2 28.7 97.4 28.1 99.6 27.9 101.8 27.1 104 26.7  
 106.2 27 108.5 26.3 110.7 26.3 112.9 26.6 115.1 26.5  
 117.3 26.7 119.5 26.7 121.7 26.8 123.9 26.8 126.2 27.1  
 128.4 27.1 130.6 27.6 132.8 27.7 135 27.9 137.2 27.9  
 139.4 28 141.7 28 143.9 28.5 146.1 28.5 148.3 29  
 150.5 29.1 152.7 29.1 154.9 29.2 157.1 29.4 159.4 29.5  
 161.6 29.5 163.8 29.6 166 29.4 168.2 29.8 170.4 29.8  
 172.6 30 174.9 29.7 177.1 29.6 179.3 29.6 181.5 29.8  
 183.7 29.7 185.9 29.8 188.1 29.4 190.3 29.9 192.6 29.8  
 199.2 29.8 205.8 30.1 210.3 30.1 212.5 29.8 214.7 29.6  
 216.9 29.6 219.1 29.7 223.5 29.7 225.8 29.5 228 29.8  
 230.2 29 232.4 29.5 234.6 29.5 236.8 29.4 239 29.4  
 241.3 29.2 243.5 29.5 250.1 29.5 252.3 30.1 254.5 30  
 256.7 30.2 259 30.2 261.2 30.3 263.4 30.3 265.6 30.7  
 267.8 30.5 270 30.8 276.7 30.8 278.9 31.5 281.1 31.6  
 285.5 31.6 287.7 31.7 289.9 31.7 292.2 31.9 294.4 32.3  
 296.6 32.4 298.8 32.3 301 31.6 303.2 31.7 305.4 31.7  
 307.7 31.8 309.9 31.4 312.1 31.4 314.3 31.5 316.5 31.7  
 318.7 32 320.9 31.8 323.1 31.7 325.4 31.7 327.6 31.6  
 329.8 31.6 332 32.2 334.2 32.1 336.4 32.1 338.6 32  
 340.9 32 343.1 32.1 345.3 32.3 351.9 32.6 354.1 33  
 360.8 33 363 33.2 365.2 33.2 367.4 33.3 369.6 33.6  
 371.8 33.6 374.1 33.8 382.9 33.8 385.1 33.9 387.3 33.9  
 389.5 34.1 391.8 34.2 394 34.1 400.6 34.1 402.8 33.7  
 405 33.7 407.3 33.4 409.5 33.2 411.7 33.3 413.9 33.1  
 416.1 33.4 418.3 33.3 420.5 33 422.7 32.8 425 32.9  
 427.2 32.6 429.4 32.8 431.6 32.2 433.8 32.5 436 32.5  
 438.2 32.6 440.5 32.4 444.9 32.2 449.3 32.2 451.5 31.8  
 453.7 32.1 455.9 32 458.2 32.3 460.4 32.3 462.6 32.4  
 464.8 32.3 467 32.5 469.2 32.5 471.4 32.3 473.7 32.3  
 475.9 32.1 478.1 31.8 480.3 31.4 482.5 31.4 484.7 31.5

486.9	31.3	489.1	31.6	498	31.6	500.2	32.1	502.4	32.2
504.6	32.2	506.9	32.3	509.1	32.4	511.3	32.2	513.5	32.4
517.9	32.4	520.1	32.2	522.3	32.2	524.6	32.1	526.8	31.8
529	31.3	531.2	31.1	533.4	31.1	535.6	30.9	537.8	31
540.1	30.7	542.3	31	544.5	30.9	546.7	31.1	548.9	30.8
551.1	30.8	553.3	30.7	557.8	30.7	560	31	562.2	31.1
564.4	31.1	566.6	31	568.8	31.1	571	30.9	573.3	31.1
575.5	31	577.7	31.1	582.1	30.7	584.3	31.1	586.5	30.9
588.7	31.3	591	31.2	593.2	32	597.6	32	599.8	32.2
602	33	604.2	33	606.5	33.2	608.7	33.3	610.9	34
613.1	34	615.3	34.2	617.5	34.2	619.7	34.4	621.9	34.4
624.2	34.8	628.6	35	630.8	35.3	633	35.1	635.2	35.3
637.4	35.3	639.7	35.9	641.9	35.9	644.1	36	646.3	35.9
648.5	36.1	652.9	36.3	659.6	36.3	661.8	37.1	664	37.1
668.4	37.3	670.6	37.3	672.9	37.5	681.7	38.3	683.9	38.8
686.1	40.1	688.3	40.4	690.6	40.7	695	41.3	697.2	41.9
699.4	42.8	703.8	43.2	706.1	43.6	708.3	43.5	710.5	44.2
712.7	44.2	714.9	45	717.1	45.2	719.3	45.7	721.5	45.8
723.8	46.2	726	46.2	728.2	46.8	730.4	47	734.8	47.6
737	48.4	739.3	48.6	741.5	50.1	743.7	50.5	745.9	51.1
748.1	51.6	750.3	51.5	752.5	52.2	754.7	52.1	757	53
759.2	53.7	761.4	54.7	765.8	56.3	768	56.3	770.2	57
772.5	57	774.7	57.4	776.9	58.3	779.1	59	781.3	60
783.5	60.9	785.7	61.2	788	61.8	790.2	62.1	792.4	62
794.6	63.1	796.8	63.3	799	63.6	801.2	63.6	803.4	64.4
805.7	64.5	807.9	65.5	810.1	65.7	812.3	65.8	814.5	66.2
816.7	66.3	818.9	66.8	821.2	66.9	823.4	67	825.6	67.5
827.8	67.5	830	67.7	832.2	67.8	834.4	67.8	836.6	68.3
838.9	68.5	841.1	68.5	845.5	68.7	847.7	69.3		

Manning's n Values                num=                3  
 Sta    n Val                Sta    n Val                Sta    n Val  
   0      .06                0      .06                847.7    .06

Bank Sta: Left    Right    Coeff Contr.    Expan.  
   0      847.7                .1      .3

Ineffective Flow                num=                2  
 Sta L    Sta R    Elev    Permanent  
   0      0      52.1      F  
   847.7    847.7    69.3      F

Upstream Embankment side slope                =                0 horiz. to 1.0 vertical  
 Downstream Embankment side slope                =                0 horiz. to 1.0 vertical  
 Maximum allowable submergence for weir flow    =                .98  
 Elevation at which weir flow begins            =  
 Energy head used in spillway design            =  
 Spillway height used in design                  =  
 Weir crest shape                                    = Broad Crested

Number of Piers = 1

Pier Data  
 Pier Station    Upstream=    411    Downstream=    411  
 Upstream        num=        2  
   Width    Elev    Width    Elev  
   6.5      20      6.5      60  
 Downstream        num=        2  
   Width    Elev    Width    Elev  
   6.5      20      6.5      60

Number of Bridge Coefficient Sets = 1

Low Flow Methods and Data  
 Energy  
 Selected Low Flow Methods = Highest Energy Answer

High Flow Method  
 Energy Only

Additional Bridge Parameters  
 Add Friction component to Momentum  
 Do not add Weight component to Momentum  
 Class B flow critical depth computations use critical depth  
 inside the bridge at the upstream end

Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION

RIVER: High

REACH: Viaduct

RS: 702

INPUT

Description:

Station	Elevation	Data	num=	339	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	52.1	2.2	50.9	4.4	50.2	6.6	49.2	8.9	49			
11.1	47.4	13.3	47	15.5	45.7	19.9	44.5	22.1	44.6			
24.3	43.4	26.6	42.4	28.8	41.8	31	40.7	33.2	41			
35.4	40.3	37.6	39.8	39.8	38.8	42.1	38.5	44.3	37.5			
46.5	37.4	48.7	36.6	50.9	36.2	55.3	35.2	57.5	35			
59.8	34.6	62	33.8	64.2	33.8	66.4	33.3	68.6	32.7			
70.8	32.8	73	32.5	75.3	32.6	77.5	32.2	79.7	32.2			
81.9	31.9	84.1	31.4	86.3	30.4	90.7	29.2	93	29.2			
95.2	28.7	97.4	28.1	99.6	27.9	101.8	27.1	104	26.7			
106.2	27	108.5	26.3	110.7	26.3	112.9	26.6	115.1	26.5			
117.3	26.7	119.5	26.7	121.7	26.8	123.9	26.8	126.2	27.1			
128.4	27.1	130.6	27.6	132.8	27.7	135	27.9	137.2	27.9			
139.4	28	141.7	28	143.9	28.5	146.1	28.5	148.3	29			
150.5	29.1	152.7	29.1	154.9	29.2	157.1	29.4	159.4	29.5			
161.6	29.5	163.8	29.6	166	29.4	168.2	29.8	170.4	29.8			
172.6	30	174.9	29.7	177.1	29.6	179.3	29.6	181.5	29.8			
183.7	29.7	185.9	29.8	188.1	29.4	190.3	29.9	192.6	29.8			
199.2	29.8	205.8	30.1	210.3	30.1	212.5	29.8	214.7	29.6			
216.9	29.6	219.1	29.7	223.5	29.7	225.8	29.5	228	29.8			
230.2	29	232.4	29.5	234.6	29.5	236.8	29.4	239	29.4			
241.3	29.2	243.5	29.5	250.1	29.5	252.3	30.1	254.5	30			
256.7	30.2	259	30.2	261.2	30.3	263.4	30.3	265.6	30.7			
267.8	30.5	270	30.8	276.7	30.8	278.9	31.5	281.1	31.6			
285.5	31.6	287.7	31.7	289.9	31.7	292.2	31.9	294.4	32.3			
296.6	32.4	298.8	32.3	301	31.6	303.2	31.7	305.4	31.7			
307.7	31.8	309.9	31.4	312.1	31.4	314.3	31.5	316.5	31.7			
318.7	32	320.9	31.8	323.1	31.7	325.4	31.7	327.6	31.6			
329.8	31.6	332	32.2	334.2	32.1	336.4	32.1	338.6	32			
340.9	32	343.1	32.1	345.3	32.3	351.9	32.6	354.1	33			
360.8	33	363	33.2	365.2	33.2	367.4	33.3	369.6	33.6			
371.8	33.6	374.1	33.8	382.9	33.8	385.1	33.9	387.3	33.9			
389.5	34.1	391.8	34.2	394	34.1	400.6	34.1	402.8	33.7			
405	33.7	407.3	33.4	409.5	33.2	411.7	33.3	413.9	33.1			
416.1	33.4	418.3	33.3	420.5	33	422.7	32.8	425	32.9			
427.2	32.6	429.4	32.8	431.6	32.2	433.8	32.5	436	32.5			
438.2	32.6	440.5	32.4	444.9	32.2	449.3	32.2	451.5	31.8			
453.7	32.1	455.9	32	458.2	32.3	460.4	32.3	462.6	32.4			
464.8	32.3	467	32.5	469.2	32.5	471.4	32.3	473.7	32.3			
475.9	32.1	478.1	31.8	480.3	31.4	482.5	31.4	484.7	31.5			
486.9	31.3	489.1	31.6	498	31.6	500.2	32.1	502.4	32.2			
504.6	32.2	506.9	32.3	509.1	32.4	511.3	32.2	513.5	32.4			
517.9	32.4	520.1	32.2	522.3	32.2	524.6	32.1	526.8	31.8			
529	31.3	531.2	31.1	533.4	31.1	535.6	30.9	537.8	31			
540.1	30.7	542.3	31	544.5	30.9	546.7	31.1	548.9	30.8			
551.1	30.8	553.3	30.7	557.8	30.7	560	31	562.2	31.1			
564.4	31.1	566.6	31	568.8	31.1	571	30.9	573.3	31.1			
575.5	31	577.7	31.1	582.1	30.7	584.3	31.1	586.5	30.9			
588.7	31.3	591	31.2	593.2	32	597.6	32	599.8	32.2			
602	33	604.2	33	606.5	33.2	608.7	33.3	610.9	34			
613.1	34	615.3	34.2	617.5	34.2	619.7	34.4	621.9	34.4			
624.2	34.8	628.6	35	630.8	35.3	633	35.1	635.2	35.3			
637.4	35.3	639.7	35.9	641.9	35.9	644.1	36	646.3	35.9			
648.5	36.1	652.9	36.3	659.6	36.3	661.8	37.1	664	37.1			
668.4	37.3	670.6	37.3	672.9	37.5	681.7	38.3	683.9	38.8			
686.1	40.1	688.3	40.4	690.6	40.7	695	41.3	697.2	41.9			
699.4	42.8	703.8	43.2	706.1	43.6	708.3	43.5	710.5	44.2			
712.7	44.2	714.9	45	717.1	45.2	719.3	45.7	721.5	45.8			
723.8	46.2	726	46.2	728.2	46.8	730.4	47	734.8	47.6			
737	48.4	739.3	48.6	741.5	50.1	743.7	50.5	745.9	51.1			
748.1	51.6	750.3	51.5	752.5	52.2	754.7	52.1	757	53			
759.2	53.7	761.4	54.7	765.8	56.3	768	56.3	770.2	57			
772.5	57	774.7	57.4	776.9	58.3	779.1	59	781.3	60			

783.5	60.9	785.7	61.2	788	61.8	790.2	62.1	792.4	62
794.6	63.1	796.8	63.3	799	63.6	801.2	63.6	803.4	64.4
805.7	64.5	807.9	65.5	810.1	65.7	812.3	65.8	814.5	66.2
816.7	66.3	818.9	66.8	821.2	66.9	823.4	67	825.6	67.5
827.8	67.5	830	67.7	832.2	67.8	834.4	67.8	836.6	68.3
838.9	68.5	841.1	68.5	845.5	68.7	847.7	69.3		

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val  
 0 .06 0 .06 847.7 .06

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.  
 0 847.7 216.91 216.91 216.91 .1 .3  
 Ineffective Flow num= 2  
 Sta L Sta R Elev Permanent  
 0 0 52.1 F  
 847.7 847.7 69.3 F

#### CROSS SECTION

RIVER: High  
 REACH: Viaduct RS: 485

#### INPUT

##### Description:

Station	Elevation	Data	num=	325							
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	19.7	2.5	19.3	5	19	14.9	19	17.3	18.4		
19.8	18	29.7	18	32.2	17.9	34.7	17.4	37.2	17		
47.1	17	49.6	16.9	52	16.1	54.5	16	84.3	16		
86.7	16.1	91.7	16.1	94.2	16.2	96.7	16.2	101.6	16		
104.1	16.1	106.6	15.9	109	16	180.9	16	183.4	16.4		
190.8	16.4	193.3	16.6	195.8	16.6	198.3	16.4	200.7	16.5		
210.6	16.5	213.1	16.8	215.6	16.7	218.1	17.2	220.6	17.2		
223	17.3	225.5	17.2	228	17.4	230.5	17.5	233	17.9		
235.4	17.9	237.9	18.1	240.4	18.2	242.9	18.6	245.3	18.6		
247.8	19	257.7	19	260.2	19.1	262.7	19.1	265.2	19.6		
267.6	20	271.8	20	273.8	20.1	275.9	20.1	277.9	20		
280	20.2	284.1	20.5	286.1	20.6	288.2	21.3	292.3	21.4		
294.3	21.5	296.4	21.5	298.4	21.6	300.5	21.6	302.5	21.4		
304.6	21.5	306.6	21.4	308.7	21.4	310.7	21.5	312.8	21.3		
314.9	21.5	316.9	21.4	319	21.5	323.1	21.4	325.1	21.7		
329.2	21.7	331.3	21.5	333.3	22.1	335.4	21.9	337.4	21.6		
339.5	21.6	341.5	22	343.6	21.6	349.7	21.6	351.8	21.7		
353.8	21.6	355.9	21.7	360	21.8	364.1	21.5	366.2	21.7		
368.2	21.2	370.3	21.6	372.3	20.9	374.4	21	376.4	21.1		
378.5	21.7	380.5	21.1	382.6	21.4	384.6	20.8	386.7	21.2		
388.7	20.8	390.8	20	392.8	19.7	394.9	19.5	396.9	19.8		
399	19.5	401	18.7	403.1	17.5	405.1	19	407.2	18.5		
409.2	18.1	411.3	17.5	413.4	19	415.4	18.2	417.5	16.7		
419.5	15.3	421.6	14.4	423.6	14.6	425.7	14.9	429.8	15		
431.8	15.2	433.9	15.9	435.9	16	438	16.2	440	17		
442.1	17.2	444.1	17.8	446.2	17.6	448.2	17.8	450.3	18		
454.4	18	456.4	17.9	458.5	18.3	462.6	18	464.7	18		
466.7	18.3	468.8	18.5	472.9	18	474.9	18.7	477	19		
479	18.9	481.1	18.8	483.1	18	485.2	17.9	487.2	17.5		
489.3	17.3	491.3	16.4	493.4	16.4	495.4	15.9	497.5	15.8		
501.6	15.3	503.6	15.8	505.7	15.6	507.7	15.5	509.8	15.4		
511.9	16.1	513.9	15.9	516	16.2	520.1	16.5	522.1	16.8		
526.2	16.8	528.3	16.5	530.3	16.8	536.5	16.8	538.5	17.3		
540.6	17.4	546.7	17.1	548.8	17	552.9	16.3	557	16.2		
561.1	15.6	563.2	15.5	565.2	15.7	567.3	15.6	569.3	15.5		
571.4	15.3	575.5	15.8	579.6	15.5	583.7	15.9	585.7	15.4		
587.8	15.4	589.8	15	591.9	15.3	593.9	14.4	596	13.9		
598	13.5	602.1	13.5	604.2	13.6	622.7	13.6	624.7	13.9		
626.8	14	630.9	14	632.9	14.1	635	14.3	637	14.8		
639.1	14.8	641.1	15.1	643.2	15	645.2	15.1	647.3	15.7		
649.3	16.3	651.4	16.7	653.4	16.9	655.5	16.9	657.6	17.1		
661.7	17.1	663.7	17.2	665.8	17.3	667.8	17.4	669.9	17.4		
671.9	17.3	676	17.3	678.1	17.2	682.2	17.3	686.3	17.3		
690.4	17.4	692.4	17.2	694.5	17	696.5	16.7	698.6	16.6		
700.6	16.5	702.7	16.3	706.8	16	782.7	16	784.8	15.9		
788.9	16	790.9	15.9	793	15.9	797.1	15.8	799.1	15.7		

801.2	15.6	805.3	15.6	807.4	15.5	813.5	15.5	815.6	15.2
819.7	15.2	821.7	15	823.8	14.9	827.9	15	840.2	15
842.2	14.9	844.3	14.6	846.3	14.4	848.4	13.6	850.4	13.4
852.5	13.4	854.6	13.2	856.6	13	860.7	13	862.8	12.9
864.8	12.9	866.9	12.6	868.9	12.5	873	12.5	875.1	12.4
883.3	12.4	885.3	12.9	887.4	13	889.4	13.2	891.5	13
893.5	13.1	895.6	13.5	897.6	13.4	899.7	13.6	903.8	13.6
905.9	14.4	910	14	914.1	14.1	916.1	14	922.3	14
924.3	13.9	926.4	13.7	930.5	13.7	932.5	14.2	938.7	14.2
940.7	14.3	942.8	14.2	944.8	14	969.5	14	971.5	14.2
973.6	14.6	977.7	15.4	981.8	15.4	983.8	15.2	985.9	15.4
987.9	15.2	990	15.2	992	15.5	994.1	15.9	996.1	16.4
998.2	16.5	1000.3	17.3	1004.4	17.5	1006.4	18.3	1008.5	18.5
1010.5	18.6	1012.6	19.7	1014.6	20	1016.7	20.1	1018.7	20.3
1020.8	20.9	1024.9	21.5	1026.9	21.8	1029	22.5	1031	23.9
1033.1	24.1	1035.1	24.5	1037.2	24.7	1039.2	25.7	1041.3	25.6
1043.3	25.8	1045.4	25.6	1047.4	27.1	1049.5	27.5	1051.6	27
1053.6	27.2	1055.7	27.5	1057.7	28.2	1059.8	28.2	1063.9	28.7
1065.9	29.9	1068	30.4	1070	30.3	1072.1	30.1	1074.1	30.7

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val  
 0 .06 864.8 .06 885.3 .06

Bank Sta:	Left	Right	Lengths:	Left	Channel	Right	Coeff	Contr.	Expan.
	864.8	885.3		322.38	322.38	322.38	.1	.3	
Ineffective Flow	num=	2							
Sta L	Sta R	Elev	Permanent						
0	840.53	15.95	F						
903.96	1074.1	15.86	F						

#### CROSS SECTION

RIVER: High  
 REACH: Viaduct RS: 162

#### INPUT

#### Description:

Station	Elevation	Data	num=	341					
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	19.9	2.2	19.7	4.3	19.1	6.5	18	8.7	17.7
10.9	17.5	13	16.7	15.2	16.3	17.4	16.3	19.6	15.1
21.7	14.8	23.9	14.1	26.1	14.1	28.2	14	50	14
52.1	13.9	54.3	13.3	58.7	13.1	60.8	13	119.5	13
121.7	12.7	123.8	12.6	126	12.1	128.2	12.1	130.4	12
221.6	12	223.8	12.2	234.7	12.2	236.8	12.3	239	12.9
241.2	13	243.3	13.2	245.5	14.2	247.7	14.8	249.9	14.3
252	14.4	254.2	13.1	256.4	12.8	258.6	11.8	260.7	10.7
262.9	9.7	269.4	9.7	271.6	10.3	273.8	10.5	275.9	10.8
278.1	11.3	280.3	11.7	282.5	12	291.2	12	293.3	12.3
295.5	12.7	297.7	13.5	299.8	13.8	302	14.4	304.2	15.5
307.8	15.6	309.9	15.5	312	15.3	314	14.7	318.2	13.9
320.3	12.9	322.4	12.6	324.5	12.4	328.7	12.2	332.9	12.2
335	12	337.1	12.2	343.4	12.2	345.5	12.1	349.6	12.1
351.7	12	366.4	12	368.5	11.7	370.6	11.7	372.7	12
379	12	381	12.4	383.1	12.6	387.3	12.6	389.4	11.6
391.5	11.5	393.6	11.3	395.7	11.2	397.8	11.3	399.9	11.2
402	11.2	406.2	11	460.6	11	462.7	11.2	466.9	11.4
469	11.4	471.1	11.3	473.2	11.7	475.3	12.5	477.4	12.2
479.5	12.2	481.5	12	485.7	12.4	487.8	13	489.9	13.1
492	12.3	494.1	12.6	496.2	13	498.3	12.9	500.4	13
502.5	13.9	505.2	13.2	507.5	13.9	509.7	13.9	512	14.1
516.4	13.7	518.7	12.1	520.9	12	523.2	11.3	525.4	11.2
527.7	11	529.9	11	532.2	11.3	534.4	11.7	536.6	11.7
538.9	12	563.6	12	565.8	12.8	568.1	11.9	570.3	11.6
572.6	11.1	574.8	11.5	577.1	12.2	579.3	13	581.6	12.4
583.8	11.5	586	11	588.3	11.9	590.5	12	592.8	12.1
595	12.7	597.3	12	599.5	12.1	601.8	11.6	604	11.2
606.3	11.5	608.5	12	610.7	11.5	613	11	615.2	11.7
617.5	12.2	619.7	12	649	12	651	12.4	653	13.3
655	13.6	657.1	13.5	659.1	13.3	663.1	13.8	665.1	13.3
667.1	13.1	669.2	12.9	671.2	12.5	673.2	12	677.2	12.3
679.2	13	681.3	12.9	683.3	12.3	687.3	12.9	691.4	12.5

693.4	12.2	695.4	12.7	697.4	13.7	699.4	14	703.5	14.4
705.5	14.9	707.5	15.1	711.5	15.2	715.6	15.2	717.6	15.6
719.6	16.3	721.6	16.6	723.6	18	727.7	19	733.7	19
735.7	18.9	737.8	18.9	739.8	18.3	743.8	18	747.8	18.6
749.9	18.6	753.9	19	755.9	18.6	759.9	19	766	19
768	18.5	770	18.7	772.1	17.8	774.1	17.5	776.1	16.4
778.1	16.3	782.1	16.1	784.2	16.5	786.2	17.3	792.2	17.6
794.2	17.5	796.3	17.2	798.3	17	800.3	17.4	802.3	17.2
806.3	17	810.4	17	812.4	16.4	814.4	16	816.4	16.6
818.5	16.4	820.5	16.1	824.5	16.3	826.5	16.8	828.5	17
830.6	15.5	832.6	14.6	834.6	14.4	836.6	13.6	838.6	13.3
840.6	13.2	842.7	13	844.7	12.9	846.7	12.6	848.7	13
852.8	13	854.8	13.3	858.8	13.3	860.8	14.9	864.9	14.1
866.9	13.6	868.9	12.7	870.9	12.1	873.3	11.4	877.5	11
904.5	11	906.6	11.1	908.7	11.3	910.8	11	914.9	11.4
917	12	919.1	12	921.2	11.8	923.2	11.4	925.3	10.4
927.4	10.3	929.5	10.1	931.6	10	935.7	10.1	937.8	10.3
939.9	10.2	942	10.4	944.1	10.4	946.1	10.2	948.2	10.6
950.3	11.1	952.4	11.7	954.5	12	964.9	12	966.9	12.1
969	12.6	971.1	13	973.2	13	975.3	13.2	977.3	13.9
979.4	14	981.5	14.4	983.6	15	985.7	15	987.7	15.6
989.8	15.7	991.9	16.3	994	16.4	996.1	16.7	998.2	16.6
1000.2	15.7	1004.4	15.7	1006.5	15.3	1008.6	15.7	1012.7	15.2
1014.8	16	1019	15.8	1025.2	14.6	1027.3	14.7	1029.4	14.6
1033.5	15	1035.6	14.8	1037.7	14.7	1039.8	14.7	1041.8	15
1050.2	15	1052.3	14.8	1054.3	14.7	1056.4	14.7	1058.5	14.5
1060.6	14.7	1062.7	14.6	1068.9	15	1071	14.7	1073.1	14.8
1075.1	14.7	1079.3	14.5	1083.5	14.5	1085.5	14.1	1087.6	14.2
1089.7	13.8	1091.8	13.2	1093.9	13	1095.9	12.4	1098	12.3
1100.1	11.7	1102.2	12	1104.3	12	1106.4	12.1	1108.4	12.4
1110.5	12.4	1112.6	11.7	1114.7	11.3	1116.8	12.3	1118.8	12.7
1120.9	12.8	1125.1	13.4	1127.2	13.8	1129.2	14.8	1131.3	15
1133.4	15	1135.5	14.6	1137.6	14.6	1139.6	14.4	1143.8	13
1148	13	1150	13.4	1152.1	13.9	1154.2	14	1156.3	13.1
1158.4	12.8	1160.5	12.7	1162.5	12.9	1164.6	12.8	1166.7	12.9
1168.8	12.6								

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val

0	.06	258.6	.06	278.1	.06
---	-----	-------	-----	-------	-----

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.  
 258.6 278.1 162 162 162 .1 .3

Ineffective Flow num= 2  
 Sta L Sta R Elev Permanent  
 0 241.06 15.39 F  
 307.67 1168.8 15.63 F

#### CROSS SECTION

RIVER: High

REACH: Viaduct

RS: 0

#### INPUT

##### Description:

Station	Elevation	Data	num=	212					
Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	41.4	2.1	39.7	4.2	38.8	6.3	37.4	8.4	35.3
10.5	33.5	12.6	33.1	14.7	31.5	16.9	29.7	19	27.9
21.1	27.5	23.2	25.3	25.3	24.5	27.4	23.2	29.5	21.7
31.6	21	33.7	20.1	35.8	18.9	37.9	18	40	17.5
42.1	16	44.2	15	46.4	14.5	48.5	14	50.6	13.3
52.7	12.9	54.8	12.7	56.9	12.7	59	12.6	61.1	12.6
63.2	12.2	65.3	12	200.1	12	202.3	11.9	210.7	11.9
212.8	11.8	217	11.8	219.1	11.7	225.4	11.7	229.6	11.5
236	11.5	238.1	11.4	240.2	11.4	242.3	11.3	254.9	11.3
257	11.2	259.1	11.3	261.2	11.5	263.4	11.7	267.6	12.1
271.8	12.1	278.1	12.4	284.4	12.4	286.5	12.6	288.6	12.6
290.7	12.3	292.8	11.8	295	11.5	297.1	11.4	299.2	11.4
301.3	11	335	11	337.1	11.3	339.2	11.8	341.3	12.1
343.4	12.2	345.5	12.1	347.6	12.2	349.7	12.2	351.8	12.4
353.9	12.4	356.1	12.7	358.2	12.9	360.3	14.9	362.4	15.4
364.5	16.2	366.6	15.8	368.7	13.8	370.8	12.9	372.9	12.6

375	12.6	377.1	12.4	381.3	12.4	383.4	12.1	385.5	11.4
387.7	11.3	389.8	11	406.6	11	408.7	11.1	410.8	11
412.9	11.4	415	11.5	417.2	11.4	419.3	11.7	421.4	12.2
423.5	12.4	425.6	12.3	427.7	12.6	429.8	12.7	430.6	13.7
432.7	15.1	434.8	15.8	436.9	16.6	439	17	441.1	16.5
443.2	15.7	447.4	13.9	449.5	13.5	451.6	13.2	453.7	13
472.7	13	481.1	12.2	483.2	12.2	485.3	12.1	489.5	12.1
491.6	12	535.7	12	537.8	12.2	539.9	12.3	542.1	12.6
544.2	12.8	548.4	13	558.9	13	561	12.8	563.1	12.4
567.3	12.2	569.4	12	603	12	605.1	11.4	607.2	11.2
611.4	11.2	613.5	10.9	615.6	11.2	617.7	11.2	619.9	11.4
622	11.8	624.1	11.8	628.3	12	664	12	666.1	12.2
668.2	12.5	670.3	12.7	672.4	12.6	674.5	12.9	676.6	12.9
678.7	12.7	682.9	12.7	685	12.1	687.1	12	693.4	12
695.5	12.1	697.7	12.3	706.1	12.7	708.2	12.9	710.3	13
1107.7	13	1109.8	13.3	1111.9	13.8	1114	14	1160.2	14
1162.3	14.3	1164.5	14.4	1166.6	14.5	1168.7	14.5	1170.8	15
1179.2	15	1181.3	14.9	1183.4	14.7	1185.5	14.6	1187.6	13.8
1189.7	13.8	1191.8	13.6	1193.9	13.1	1196	12.4	1200.2	12
1208.6	12	1210.7	12.2	1212.8	12.6	1214.9	12.8	1219.1	13
1244.4	13	1246.5	13.2	1248.6	13.7	1250.7	13.9	1252.8	13.9
1254.9	14	1315.8	14	1317.9	14.2	1320.1	14.3	1322.2	14.4
1326.4	14.4	1328.5	14.9	1330.6	15.1	1341.1	15.1	1343.2	15.3
1345.3	15.3	1347.4	15.4	1351.6	15.4	1353.7	15.7	1355.8	15.6
1357.9	15.2	1360	14.6	1362.1	13.8	1364.2	13.6	1366.3	12.5
1368.4	11.6	1370.5	11.5	1372.6	11	1376.8	11.2	1378.9	11.1
1381	11.2	1383.1	11						

Manning's n Values num= 3  
 Sta n Val Sta n Val Sta n Val  
 0 .06 387.7 .06 412.9 .06

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.  
 387.7 412.9 0 0 0 .1 .3

Ineffective Flow num= 2  
 Sta L Sta R Elev Permanent  
 0 362.64 17.18 F  
 441.59 1383.1 17.83 F

#### SUMMARY OF MANNING'S N VALUES

River:High

Reach	River Sta.	n1	n2	n3
Viaduct	1054	.06	.06	.06
Viaduct	930	.06	.06	.06
Viaduct	816	Bridge		
Viaduct	702	.06	.06	.06
Viaduct	485	.06	.06	.06
Viaduct	162	.06	.06	.06
Viaduct	0	.06	.06	.06

#### SUMMARY OF REACH LENGTHS

River: High

Reach	River Sta.	Left	Channel	Right
Viaduct	1054	124	124	124
Viaduct	930	228	228	228
Viaduct	816	Bridge		
Viaduct	702	216.91	216.91	216.91
Viaduct	485	322.38	322.38	322.38
Viaduct	162	162	162	162
Viaduct	0	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS  
 River: High

Reach	River Sta.	Contr.	Expan.
Viaduct	1054	.1	.3
Viaduct	930	.1	.3
Viaduct	816	Bridge	
Viaduct	702	.1	.3
Viaduct	485	.1	.3
Viaduct	162	.1	.3
Viaduct	0	.1	.3

Profile Output Table - Standard Table 1

Reach Slope	River Sta Vel	Profile Chnl	Q Total Flow Area	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G.
	(ft/ft)	(ft/s)	(sq ft)	Top Width	Froude # Chl	(ft)	(ft)	(ft)
Viaduct 0.002004	0 2.72	50-year 197.09	464.00 1277.08	11.00 0.24	14.90	13.00	14.99	
Viaduct 0.002001	0 2.85	100-year 215.04	530.00 1305.79	11.00 0.25	15.17	13.12	15.27	
Viaduct 0.002003	0 3.12	500-year 255.02	685.00 1328.93	11.00 0.25	15.77	13.39	15.89	
Viaduct 0.001896	162 3.05	50-year 189.59	464.00 985.10	9.70 0.24	15.20	12.91	15.31	
Viaduct 0.002168	162 3.32	100-year 198.54	530.00 994.77	9.70 0.26	15.34	13.10	15.47	
Viaduct 0.000013	162 0.28	500-year 3377.75	685.00 1027.71	9.70 0.02	15.91	13.48	15.91	
Viaduct 0.003368	485 3.17	50-year 167.04	464.00 309.84	12.40 0.31	15.79	14.32	15.91	
Viaduct 0.001638	485 2.26	100-year 315.65	530.00 320.86	12.40 0.22	15.90	14.42	15.95	
Viaduct 0.002882	485 2.98	500-year 310.43	685.00 317.49	12.40 0.29	15.86	14.71	15.95	
Viaduct 0.048194	702 6.62	50-year 70.09	464.00 51.58	26.30 1.00	28.68	28.68	29.36	
Viaduct 0.046894	702 6.86	100-year 77.25	530.00 52.77	26.30 1.00	28.81	28.81	29.54	
Viaduct 0.045965	702 7.08	500-year 96.73	685.00 62.07	26.30 1.00	29.16	29.16	29.94	
Viaduct 816		Bridge						
Viaduct 0.010003	930 2.20	50-year 210.82	464.00 251.02	42.30 0.42	44.27	43.71	44.34	
Viaduct 0.010008	930 2.27	100-year 233.13	530.00 264.46	42.30 0.43	44.35	43.77	44.43	
Viaduct 0.010055	930 2.47	500-year 277.15	685.00 278.24	42.30 0.44	44.51	43.95	44.61	
Viaduct 0.054869	1054 5.45	50-year 85.16	464.00 93.21	49.70 1.00	51.59	51.59	52.05	
Viaduct 0.055675	1054 5.68	100-year 93.29	530.00 96.95	49.70 1.02	51.67	51.67	52.18	
Viaduct	1054	500-year	685.00	49.70	51.87	51.87	52.45	

0.050703      6.08      112.75      98.74      1.00

**Appendix C: Structure Plans**

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LIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
4	SF	101		15	

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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San Francisco, CA 94105

**NOTES:**

1. For Sections A-A, B-B & C-C, see "Typical Section 1" sheet.
  2. For Sections D-D & E-E, see "Typical Section 2" sheet.
  3. Proposed location of mechanical jet fans, if required for ventilation. Jet fans require a minimum 2 foot recess in the roof slab over an approximate length of 75 feet.

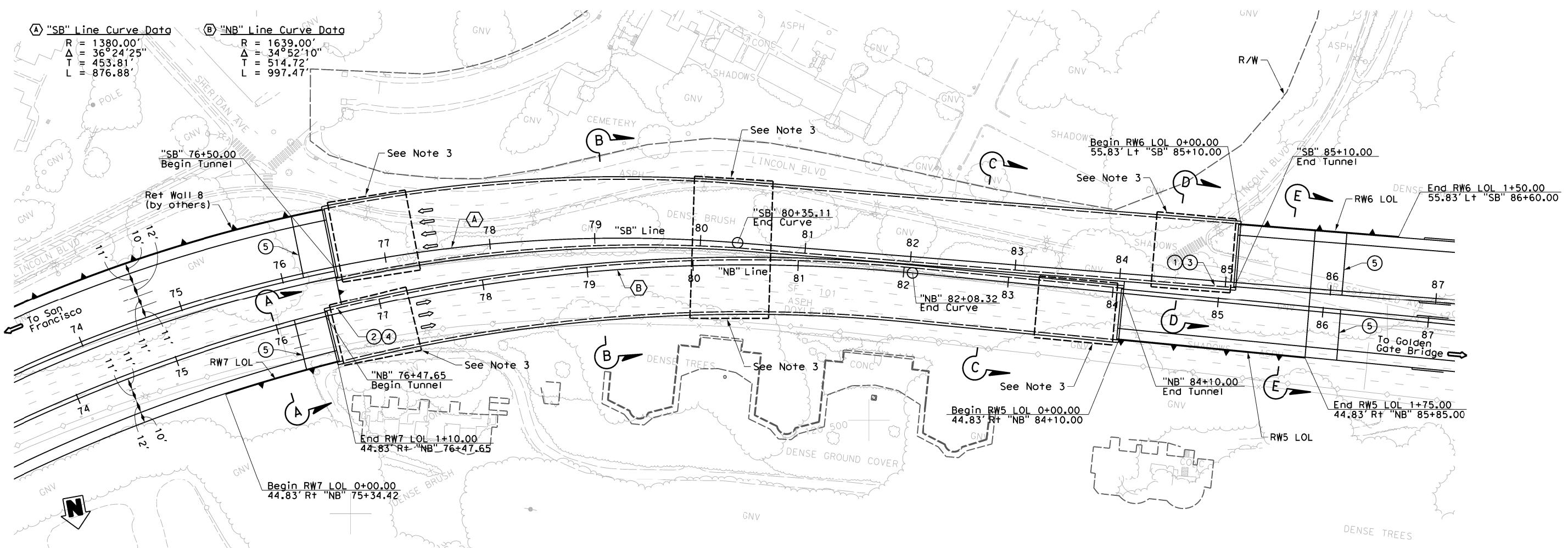
**LEGEND:**

- ① Paint "Bridge No. 34-0161L"
  - ② Paint "Bridge No. 34-0161R"
  - ③ Paint "Battery Tunnel SB"
  - ④ Paint "Battery Tunnel NB"
  - ⑤ Structure Approach Type N (30D)

*e State of California or its officers*

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## **PLAN**

Scale: 1"=50'

PAGE S301

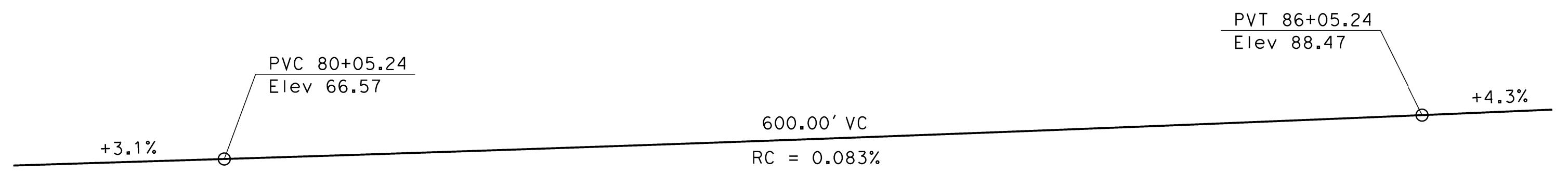
X	DESIGN	BY	CHECKED X	LOAD RESISTANCE FACTOR DESIGN	LIVE LOADING: HL 93 W/ "LOW-BOY"; PERMIT DESIGN VEHICLE	PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION			BRIDGE NO.	BATTERY TUNNEL GENERAL PLAN	
DESIGN OVERSIGHT	DETAILS	BY	CHECKED X	LAYOUT	BY	CHECKED X		34-0161L/R			
X	QUANTITIES	BY	CHECKED X	SPECIFICATIONS BY X		PLANS AND SPECS COMPARED X	PROJECT ENGINEER	POST MILES			
SIGN OFF DATE											
DESIGN GENERAL PLAN SHEET (ENGLISH) (REV. 2/25/05)					ORIGINAL SCALE IN INCHES FOR REDUCED PLANS	0 1 2 3	CU 04 EA 163700	DISREGARD PRINTS BEARING EARLIER REVISION DATES →	REVISION DATES (PRELIMINARY STAGE ONLY)		SHEET OF

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
4	SF	101			16

REGISTERED CIVIL ENGINEER DATE  
 REGISTERED PROFESSIONAL ENG.  
 NO. \_\_\_\_\_  
 EXP. \_\_\_\_\_  
 STATE OF CALIFORNIA \*

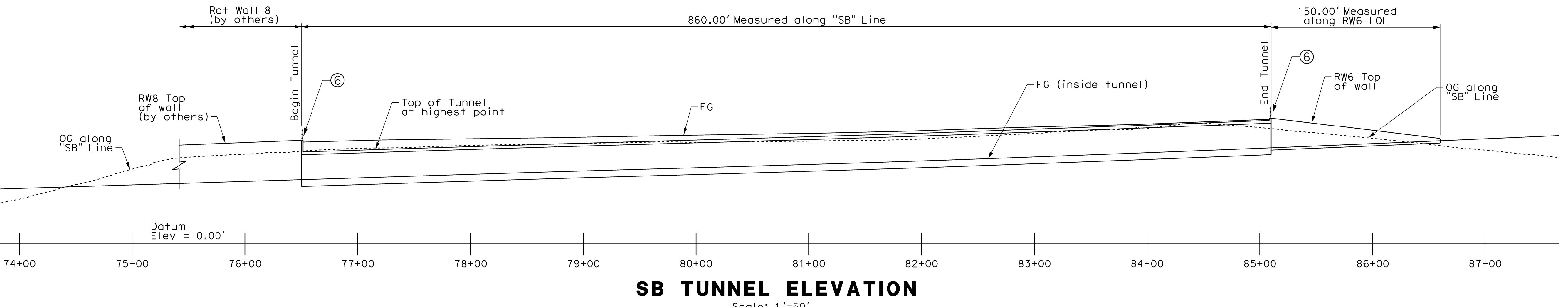
PLANS APPROVAL DATE  
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 completeness of electronic copies of this plan sheet.

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 560 Mission Street, Suite 700  
 San Francisco, CA 94105



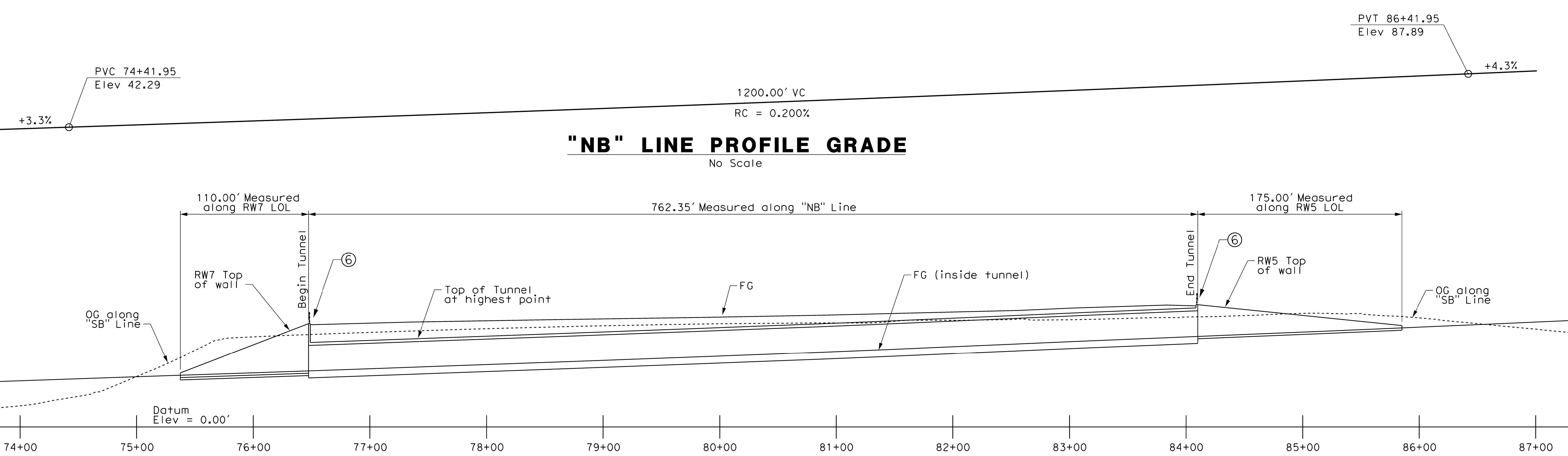
### "SB" LINE PROFILE GRADE

No Scale



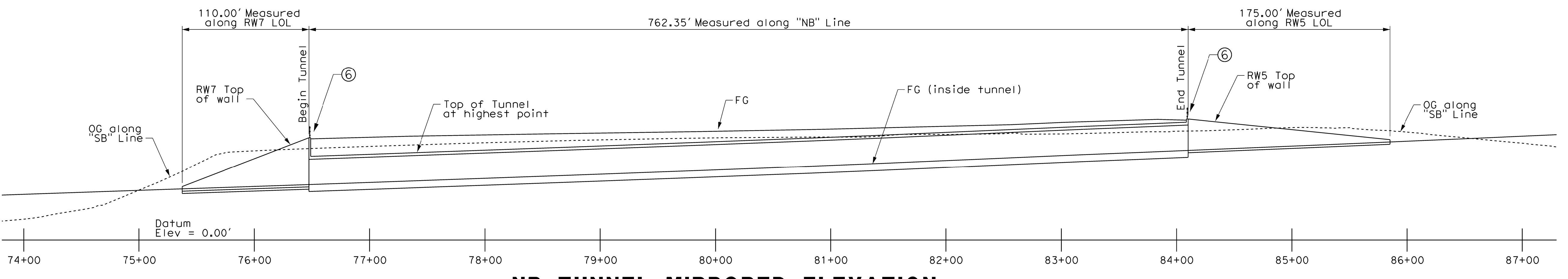
#### NOTE:

- Elevations are shown at the centerline of tunnel structures.



### "NB" LINE PROFILE GRADE

No Scale



#### LEGEND:

- (6) Architectural fence

### NB TUNNEL MIRRORED ELEVATION

Scale: 1"=50'

PAGE S302

X	DESIGN	BY	CHECKED X	LOAD RESISTANCE FACTOR DESIGN	LIVE LOADING: HL 93 W/ "LOW-BOY"; PERMIT DESIGN VEHICLE		
DESIGN OVERSIGHT	DETAILS	BY	CHECKED X	LAYOUT	BY	CHECKED X	
X	QUANTITIES	BY	CHECKED X	SPECIFICATIONS	BY X	PLANS AND SPECS COMPARED X	

DESIGN GENERAL PLAN SHEET (ENGLISH) (REV. 2/25/05)

PREPARED FOR THE  
STATE OF CALIFORNIA  
DEPARTMENT OF TRANSPORTATION

PROJECT ENGINEER

BRIDGE NO.  
34-0161L/R  
POST MILES

BATTERY TUNNEL  
ELEVATION

ORIGINAL SCALE IN INCHES  
FOR REDUCED PLANS

0

1

2

3

CU 04  
EA 163700

DISREGARD PRINTS BEARING  
EARLIER REVISION DATES

REVISION DATES (PRELIMINARY STAGE ONLY)